The vertebrate fauna of the Clemant State Forest Lowlands: a significant coastal woodland remnant in the southern wet tropics bioregion, North-eastern Queensland

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ABSTRACT

A survey of vertebrate fauna was conducted in the lowlands of Clemant State Forest, a 5430 ha area of land that lies at the southern extremity of the Wet Tropics Bioregion, north of Townsville. The fauna of the area was previously poorly known and few surveys had been undertaken. Two week-long surveys were conducted per year between 1997 and 2002 for each of 31 survey sites comprising 15 regional ecosystems. Survey methods at each site included pitfall-traps, Elliott and cage traps, reptile searches, and one-hectare bird counts. Incidental data were also collected outside sample sites via spotlighting, harp trapping, trip-lines, ultrasonic bat detection, and general observations. A total of 7365 records representing 274 species of vertebrate fauna were recorded, comprising 158 bird species, 20 amphibians, 41 mammals and 55 reptiles. The total number of species including those recorded in other surveys is 294, which represents almost 50% of the vertebrate fauna species identified for the Wet Tropics Bioregion. Fourteen species are listed of conservation significance and several others are of regional significance. Relationships with regional ecosystems were investigated and many species were strongly associated with particular ecosystems. Seasonal variation and adequacy of survey methods were also examined. The results of this survey show that this area is at least as diverse and significant for fauna as any other part of the Wet Tropics (including rainforest). Hobby farming and agriculture is beginning to expand in these southern parts, where native vegetation is currently in good condition. Formation of a system of reserves for this area, as well as changes to the management of private lands, is essential in the very near future in order to prevent irreversible loss of a highly significant flora and fauna.

Key words: coastal lowlands, fauna, survey methods, Wet Tropics, Northern Brigalow Belt, biogeography, conservation

Introduction

The Wet Tropics bioregion of Queensland is typically considered to be a landscape characterised by high rainfall, with vast mountainous tracts of rainforest and tall *Eucalyptus* forests, and wet coastal swamp complexes comprising dense tea-tree stands, mangroves and vine scrubs (Tracey 1982; Goosem 2000). The lowland country in the southern-most portion of the Wet Tropics is very different to this. The southern boundary of this bioregion lies only 30 km north of Townsville, where it abuts the extensive dry tropical savannas of the Brigalow Belt bioregion (Sattler and Williams 1999). Having a lower and more marked monsoonal rainfall pattern than the majority of the Wet Tropics (<1500mm compared to 2000-8000 mm per annum, Nix and Switzer 1991), this area typically lacks rainforest with the exception of narrow riparian bands on some creeks.

The majority of fauna research and assessment in the Wet Tropics bioregion has been undertaken in the central and northern uplands, and most often in rainforest (Winter *et al.* 1992). A recent biogeographic review and summary of fauna research in the bioregion identified that studies often specifically exclude woodlands, and particularly lowland areas (Williams *et al.* 1996). Some surveys have been undertaken in the southern portions of the Wet Tropics albeit in upland areas (e.g. Mt Halifax Williams *et al.* 1993a; Graham 1991), while limited data exists from the southern coastal woodlands (Lavery 1968; Lavery and Johnson 1968; Lavery and Grimes 1974a, 1974b; WBM Oceanics 1993; Winter *et al.* 1992; Braby 1992). It is clear that past research has focussed almost exclusively on the values of rainforest areas in the Wet Tropics to the detriment of the less charismatic drier woodlands. Ironically the coastal lowland woodland mosaics are the most threatened ecosystems of the Wet Tropics, being some of the most extensively cleared (>60%) native vegetation in north Queensland (Queensland Herbarium, Environmental Protection Agency 2003a).

Clemant State Forest is a significant segment of Wet Tropics vegetation, extending from near the top of the Paluma Range, east to the coastal esplanade. This State

Forest is of particular importance being one of the few continuous tracts of native vegetation in the Wet Tropics that extends from the eastern seaboard to the upland rainforest, and west into the Einasleigh Uplands. Despite this landscape connectivity and its proximity to Townsville, fauna and flora data for the area were minimal.

The current fauna survey of Clemant State Forest was therefore an attempt to rectify an apparent gap in fauna data in the lowlands of the Wet Tropics bioregion. This paper reports the results of a long-term vertebrate fauna survey, with particular emphasis on relationships between fauna and regional ecosystems, seasonal differences and the biogeographical patterns of the fauna in the context of the Wet Tropics and Northern Brigalow Belt bioregions. In addition, significant species, communities and regional ecosystems are discussed. Finally this information is used to briefly identify the conservation values and reservation status of the southern Wet Tropics coastal lowlands.

Methods

Study Area

Clemant State Forest (hereafter Clemant) is situated 40 km north-west of Townsville and extends from near the top of the Paluma Range, east to the 11km wide coastal esplanade. The total area is 11050 ha, of which approximately 5430 ha are coastal lowlands (defined as the area east of the break in slope forming the boundary of mountainous and alluvial terrain) which is the area covered by this survey (Figure 1). Clemant is situated within the Wet Tropics, close to the boundary of the Northern Brigalow Belt.

The study area is located within the Herbert subregion of the Wet Tropics bioregion (Sattler and Williams 1999; Environmental Protection Agency 2003a). This subregion is characterised by alluvial processes (dominated by the extensive Herbert River floodplain), and has the lowest rainfall of any of the lowland subregions in the Wet

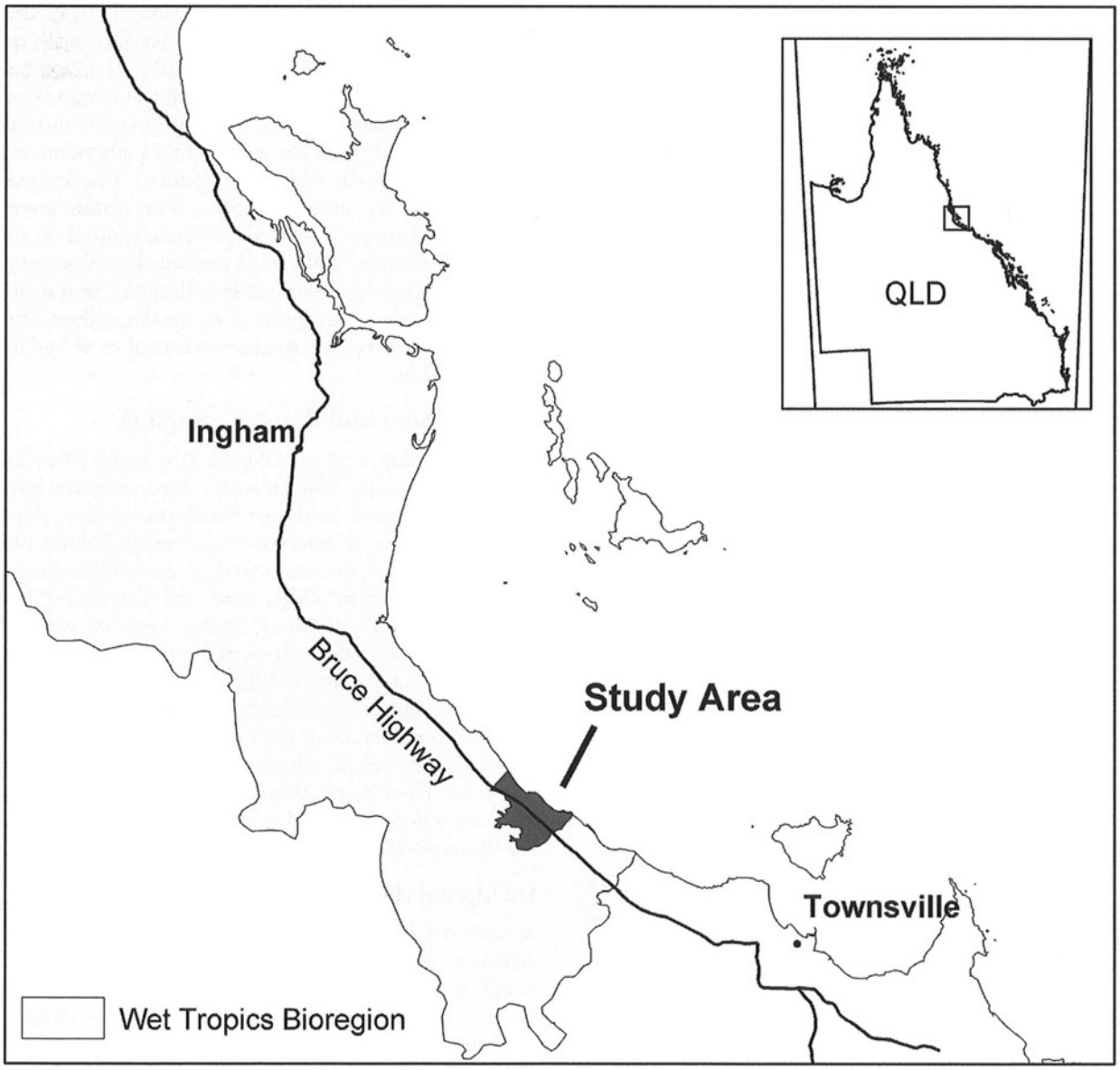

Figure 1. Location of the Clemant State Forest lowlands study area. Note the proximity to the edge of the Wet Tropics bioregion boundary (Brigalow Belt bioregion to the south and Einasleigh Uplands bioregion to the West).

Tropics. Its natural vegetation is dominated by woodlands and open forests rather than having extensive areas of rainforest typical to other subregions. The landform of the Clemant lowlands consists of a moderately narrow, very gently sloping alluvial plain with a combination of well-drained alluvial fans and prior in-filled streams, fertile well-drained creek terraces, and alluvial soils of impeded drainage ranging from fine sandy clay to heavy clay soils. A well-developed Holocene dune ridge borders the coastline, and there are two Pleistocene dunes (now separated from the coast by alluvial plain) with greater soil development. A few small hills occur as isolated outcrops.

The better-drained alluvial soils support eucalypt woodland, with Clarkson's Bloodwood *Corymbia clarksoniana*, Poplar Gum *Eucalyptus platyphylla*, and *Acacia* species, whilst the alluvial fans and small hills support White Mahogany *E. acmenoides*, Gympie Messmate *E. cloeziana*, and Broad-leaf Ironbark *E. drepanophylla*. The areas of impeded drainage are dominated by Broad-leaf Tea-tree *Melaleuca viridiflora*, which range from those with sandy-clay soils with Grass Tree *Xanthorrhoea johnsonii* and Kangaroo Grass *Themeda triandra*, to slightly lower areas with heavy clay soils, debil-debil development and specialist swamp grasses such as *Ischaemum australe*. A few, more-permanent swamps contain a dense forest of the taller, undescribed *Melaleuca* sp. aff. *viridiflora*, with aquatic grasses and sedges. The young coastal dunes are densely forested by Moreton Bay Ash *Corymbia tessellaris*, *Acacia* spp., and vine forest species, whilst the older dunes consist of open forest with *C. tessellaris*, *C. clarksoniana* and *Acacia* spp.

Site selection

Land type mapping (Kemp *et al.* 1999) and regional ecosystem mapping (Queensland Herbarium, Environmental Protection Agency 2003b) was used to stratify and identify the quadrat sampling sites. A minimum of two quadrats was surveyed per regional ecosystem, with a greater effort being skewed to those with a larger geographical spread and/or floristic variation. Twelve of the fifteen regional ecosystems occurring in the study area were sampled using quadrat-based methods (Table1). The remaining three regional ecosystems (mangroves, swamp paperbark open forest and riparian rainforest) were sampled using only incidental data because they were either not practical to sample systematically (RE 7.1.1), or were of very restricted distribution within the study area (REs 7.3.5 and 7.3.23). To aid clarity in the presentation of the results, the REs are grouped into six broad habitats: estuarine, closed/clumped forest, grassland, paperbark swamp, tea-tree woodland and eucalypt open forest (Table 1).

Where possible, quadrats were positioned more than 50 m from the nearest vegetation unit edge, and more than 20 m from fence-lines or tracks. All quadrats were located at least 300 m from another quadrat. A total of 31 quadrats were sampled (Table 1), 30 sampled twice, post-wet and pre-wet. Post-wet season samples were conducted after the summer rains, generally in the period from March to May, whilst pre-wet refers to the build-up period prior to the onset of tropical summer rains, typically during October and November. The remaining single site (Site 17) was sampled only once (in the October-November period), due to insurmountable problems of access.

Vertebrate fauna sampling

The vertebrate fauna survey of Clemant was conducted between 1997 and 2002. Eight field surveys were undertaken, each of one week duration. These took place in October 1997, April 1998, October 1998, October 1999, May 2000, April 2001, November 2001 and April 2002. Several additional trips of shorter duration took place for the purposes of incidental data collection (particularly for frogs).

The vertebrate sampling was primarily conducted using a standardised quadrat (a nested trap and search array), modified from Woinarski and Fisher (1995a). The base quadrat area was a 50 x 50 m square demarcated by 20 Elliott traps (type A, 10 x 10 x 33 cm folding aluminium live trap) placed 10 m apart along the perimeter and two cage traps placed at opposing corners. Four pitfalls arranged in a 'T' configuration (30 and 20 m of drift fence) were placed along one edge of this array, with the stem of the 'T' projecting into the quadrat. All Elliott and cage traps were baited with peanut butter, honey and oats, and alternately supplemented with pet (dog/cat) biscuits. Traps were checked in the morning and afternoon and opened for a six-day (144 hour) period. Trapping was supplemented by timed searches: four instantaneous morning bird counts within a 1 ha area, centred on the 50 x 50 m quadrat, and two (2 person) diurnal searches each of 10 minute duration conducted within the trapping square. Diurnal counts included active (log rolling, litter raking) and passive (looking for movement or at basking areas) searches.

Environment and floristic sampling

For each quadrat, a range of floristic (species presence and cover), structural (foliage projective cover of strata, basal area, canopy cover), landscape (landform, position, slope, aspect, patch size, location of water-bodies), habitat (soil type and structure, termite mounds, rock, litter, hummock grass, tussock grass, sedge, forb and log cover) and disturbance (fire, feral, weed, erosion impacts) variables were recorded (see detailed methods in Kutt 2004a). For each 50 x 50 m quadrat, floristic data were recorded each time it was sampled for fauna. Only plants with at least 2 % cover were identified. Data collected included species name; average height; foliage projective cover and crown cover. Any plant species that could not be identified in the field was collected for further examination, or was sent to the Queensland Herbarium in Brisbane for identification.

Incidental data and secondary sources

Incidental data were collected throughout all formal survey activities, including site reconnaissance and vegetation sampling. Each record was geo-coded using a single GPS reading. Regional ecosystems where no formal sampling occurred were targeted by incidental searches. These records were obtained via active searching, bat (harp) trapping and ultrasonic detection (Anabat). Calls recorded from the ultrasonic bat detectors were reviewed and identified

Table 1. Regional Ecosystems, site localities, number of quadrats per site and general habitat type for each quadrat sampled. Regional ecosystem number is taken from Environmental Protection Agency, (2003b). Descriptions have been modified slightly to represent the local variation at Clemant State Forest. Areas (Ha) are adapted from Kemp *et al.* (1999), and Queensland Herbarium, Environmental Protection Agency (2003b). Site 17 is marked with an asterisk to distinguish it as the only site which was sampled only once (pre-wet). Incid. = incidental data only. Datum is in WGS84.

RE	Habitat	Description	Area in Clemant	Site	Easting	Northing
7.1.1	Estuarine	Mangrove forests on coastal lowland, saline soils.	85	Incid.		
7.1.2	Estuarine	Salt meadow/ herbfield on coastal lowland hyper–saline soils.	84	2	448372	7887562
				24	441162	7891905
7.2.3	Closed/ clumped forest	Dune ridges behind the strandline, with Moreton Bay Ash (*Corymbia tessellaris*), *Acacia* spp. Red Ash (*Alphitonia* excelsa) and vine (beach) scrub species, open to closed forest.	207	3	446842	7887823
				4	447874	7887267
7.2.3x2	Closed/ clumped forest	Strandline vegetation with scattered trees including Quinine tree (*Petalostigma pubescens*) and Coast Sheoak (*Casuarina equisetifolia*), and clumps of vine (beach) scrub.	103	5	447914	7888002
				6	448089	7888099
7.2.4	Closed/ clumped forest	Clarkson's bloodwood (*Corymbia clarksoniana*), Moreton Bay Ash (*C. tessellaris*), and *Acacia* spp., open forest on old stranded dune ridges.	88	20	440361	7891996
				21	440285	7892402
7.3.1	Grassland	Grassland of *Themeda triandra* on old marine plains.	39	17*	441645	7891508
7.3.5	Paperbark swamp	Swamp paperbark (*Melaleuca quinquenervia*) open forest on poorly drained lowlands.	3	Incid.		
7.3.6x1	Paperbark swamp	Weeping paperbark *(Melaleuca leucadendra)* open forest on poorly drained lowlands.	10	18	441086	7892163
				23	441185	7891534
7.3.7x1	Paperbark swamp	Broad-leaf tea tree (*Melaleuca* sp. aff. *viridiflora*) closed forest in seasonally inundated shallow drainage lines.	30	19	442090	7888782
7.3.8	Tea-tree woodland	Broad–leaf tea tree (*Melaleuca viridiflora*) open forest to woodland on poorly drained lowlands.	1820	1	446356	7887962
				7	445269	7885891
				8	445521	7885122
				12	442959	7884455
				30	439793	7891327
				31	441751	7887847
7.3.19	Eucalypt open forest	Clarkson's bloodwood (*Corymbia clarksoniana*), Poplar Gum (*Eucalyptus platyphylla*), *Acacia* spp. open forest on lowland alluvials.	1357	11	443396	7883986
				14	442687	7885384
				15	443221	7886164
				16	441181	7888194
				22	440759	7892453
				28	442202	7887972
				2	440956	7889091
7.3.20	Eucalypt open forest	White Mahogany (*Eucalyptus portuensis*), +/- Gympie Messmate *(E. cloeziana)*, +/- Clarkson's Bloodwood (*Corymbia clarksoniana*), +/- Pink Bloodwood (*C. intermedia*) on colluvial fans.	532	25	440610	7889686
				27	438909	7887060
7.3.23	Closed/ clumped forest	Simple-complex mesophyll vine forest on creek banks and levees.	25	Incid.		
7.3.25	Closed/ clumped forest	Weeping paperbark *(Melaleuca leucadendra)* and/or *M. fluviatilis* open forest with vine forest elements, on creek banks and levees.	192	9	443732	7883342
				13	442418	7885093
7.12.31	Eucalypt open forest	Mixed eucalypt woodland or open forest on low foothills. Includes White Mahogany (*Eucalyptus portuensis*), Poplar Gum (*E. platyphylla*), Clarkson's Bloodwood (*Corymbia clarksoniana*), Narrow-leaved Ironbark (*E. drepanophylla*) and Silver -leaved Ironbark (*E. melanophloia*).	432	10	442874	7884834
				26	440668	7889189

(by ASK) by comparison with an extensive reference library of sequences recorded for north-east Queensland. Active searching included both diurnal observation and spotlighting for nocturnal species. Approximately 21 harp trap, three mist net, one trip-line nights, 4.5 detector hours (opportunistic rather than continuous) and 52 spotlight hours were undertaken throughout the survey. Data from previous surveys were also gathered, and these sources included: WBM Oceanics (1993), Winter *et al.* (1992), the Queensland Museum collections database and the Birds Australia Atlas database.

Analysis

All quadrat and incidental data were assigned a regional ecosystem type (as per Environmental Protection Agency 2003b) by field assessment and referral to the current Wet Tropics Bioregion regional ecosystem mapping available for the region (Queensland Herbarium, Environmental Protection Agency 2003b). Variation in the abundance of species in the standardised quadrat samples across the regional ecosystems was examined via nonparametric (Kruskal-Wallis) one-way analysis of variance. Only species recorded in three or more quadrat samples were considered in this analysis. Significant variation across regional ecosystems in the ground cover habitat variables was also investigated using one-way ANOVA. The frequency of occurrence of each species in the total quadrats sampled in each regional ecosystem type was also calculated to further explore relationships with regional ecosystems.

The seasonal variation in abundance of species in the regional ecosystems that were sampled in both the pre-wet and post-wet periods was examined using the Wilcoxon matched pairs test statistic. The significant differences in the seasonal groundcover variables were also assessed using this test.

The success (or redundancy) of each survey method in contributing to the total species pool recorded for Clemant was tested by examination of the total frequency (for each taxa) of species recorded uniquely by any single survey method was tabulated and graphed. Though it may seem spurious to compare techniques designed to target specific fauna taxon (e.g. bird counts versus bat trapping), the intent of this section is to reinforce the notion that a complete assessment of the potential fauna of a region is only possible using the full array of available techniques.

Taxonomy

Common and scientific names for vertebrate fauna follow the current taxon list of fauna and flora for Queensland (Environmental Protection Agency 2003c). Only common English names (Christidis and Boles 1994) are used for birds in the results and discussion sections of the paper. Scientific names are used for all other vertebrate fauna species. This aids clarity and readability as common names are of standard usage for birds, whereas for other taxa, scientific names are more meaningful as agreed and workable common names are not available despite attempts to define these (Stanger *et al.* 1998). Species ordering in tables reflects taxonomic ordering. Families, scientific names, and where applicable common names, are listed for all species in Appendix 1.

Scientific plant names were taken from Henderson (2002) and updates in Queensland Herbarium, Environmental Protection Agency (2003c). Common plant names also follow the current taxon list of fauna and flora for Queensland (Environmental Protection Agency 2003c).

Any animals trapped that could not be confidently identified by reference to existing field guides were collected and sent to the Queensland Museum for verification. There were a number of fauna species with problematic identifications. The Queensland Museum has identified both *Carlia aeratus* and *Carlia foliorum* (both formerly *Lygisaurus*) from specimens collected during the survey. However, the two were not easily distinguished in the field either by habitat partitioning or via morphological means (fixed or movable spectacle on the eye). We therefore treated these species as a complex (*Carlia aeratus/foliorum*) in the data. The genus *Eulamprus* (Scincidae) has been recently revised (Greer 1992), however the division of *E. sokosoma* and *E. brachysoma* by overlapping mid-body scale counts in the field was found to be difficult and ambiguous, such that the two species were unable to be separated. As a result we treat these species as a complex and refer to them by their old name *E. tenuis*. Clemant lies within the zone of intergradation and overlap for Gould's/Little Bronze Cuckoo. Field call and morphological characteristics are again confusing. We were unable to consistently distinguish these two species in the field and therefore refer to them as a complex.

Results

Species

A total of 7365 records representing 274 species of vertebrate fauna was recorded from this survey for the Clemant lowlands, comprising 158 bird species, 20 amphibians, 41 mammals and 55 reptiles (Table 2 and 3). When records from other surveys are included, the total number of vertebrate fauna species (excluding fish) for Clemant is 294 (Appendix 1). The number of species recorded represents almost 50% of the fauna species identified for the Wet Tropics bioregion (Williams *et al.* 1996). The most abundant species recorded of each major taxon in the quadrat samples included: Mistletoebird, Leaden Flycatcher, Peaceful Dove, Bar-shouldered Dove and White-bellied Cuckoo-Shrike (birds); *Bufo marinus*, *Limnodynastes ornatus*, *L. convexiusculus*, *Uperoleia mimula*, *Litoria nasuta* (amphibians); *Melomys burtoni*, *Pseudomys delicatulus*, *Pteropus alecto*, *Petaurus breviceps*, *Rattus sordidus* (mammals); and *Carlia storri*, *Cryptoblepharus virgatus*, *Carlia aeratus/foliorum*, *Diporiphora australis*, and *Gehyra dubia* (reptiles).

A number of species were recorded at the limits of their known distribution and habitat, which was expected given the geographic location of Clemant at the boundary of the Northern Brigalow Belt and Wet Tropical bioregions. These included the more typically upland tall forest and rainforest-dwelling species such as the Topknot Pigeon, Wompoo Fruit-Dove, Pale-yellow Robin, Pied Monarch, Bridled Honeyeater, Macleay's Honeyeater, *Perameles nasuta*, *Litoria infrafrenata*, *Carlia rubrigularis*, *Hemisphaeriodon gerrardii* and *Saproscincus basiliscus*

Table 2. All species recorded in the quadrat samples. Data provided are the species abundance and taxa richness sample mean per regional ecosystem. The number in parentheses is the frequency occurrence of that species in all quadrats recorded within a single regional ecosystem type. The correlation coefficient (H) and the significance in variation in abundance were tested via Kruskal-Wallis ANOVA. Probability levels are *p<0.5, **p<0.01, ***p<0.001. The RE 7.3.1 was omitted as only was sample (pre-wet) was conducted. Only species recorded in three or more regional ecosystems were considered in the analysis. For significant result the highest five scores (if applicable) are indicated in bold. Species are ordered from most abundant to least abundant from left to right across the regional ecosystems. CCF = closed/clumped forest; EOF = eucalypt open forest; EST = estuarine; PS = paperbark swamp; TTW = tea-tree woodland. Complete taxonomic order of species including family is presented in Appendix 1.

Species	7.2.3	7.2.3x2	7.2.4	7.3.25	7.12.31	7.3.19	7.3.20	7.1.2	7.3.6x1	7.3.7x1	7.3.8	H	p
Broad habitat	CCF	CCF	CCF	CCF	EOF	EOF	EOF	EST	PS	PS	TTW		
No. of quadrats	2	2	2	2	2	7	2	2	2	1	6		
No. of samples	4	4	4	4	4	14	4	4	4	2	12		
Total species richness	72	54	57	70	50	94	54	60	63	35	94	21.9	*
Bird richness	48	33	32	48	26	56	34	45	41	20	60	22.9	*
Amphibian richness	5	3	5	8	4	8	3	1	7	8	10	22.2	*
Mammal richness	7	5	7	2	5	11	6	6	7	2	10		ns
Reptile richness	12	13	13	12	15	19	11	8	8	5	14	25.7	**
Quadrat species richness	**38.8**	**29.0**	**28.0**	**34.5**	22.8	26.5	23.8	21.8	26.3	22.0	**26.7**	21.9	*
Quadrat bird richness	**26.0**	16.3	**16.5**	**24.0**	12.0	16.4	16.3	**16.5**	**16.5**	11.0	16.3	22.9	*
Quadrat amphibian richness	**2.5**	2.0	2.3	**4.0**	1.3	**2.5**	1.3	0.3	**2.8**	**6.0**	**3.3**	22.2	*
Quadrat mammal richness	**3.3**	**3.0**	**2.8**	1.3	1.5	2.5	2.3	2.3	**3.5**	1.5	2.5		ns
Quadrat reptile richness	7.0	7.8	**6.5**	**5.3**	**8.0**	5.1	4.0	2.8	3.5	3.5	4.6	25.7	**
BIRDS													
White-throated Honeyeater	**3.5 (75)**		**4.8 (100)**	0.5 (50)	1.3 (50)	**2.86 (92)**	**7.3 (100)**	0.5 (25)	**3.5 (100)**	2.5 (50)	2.8 (83)	26.6	**
Rainbow Lorikeet	3.2 (100)	0.8 (25)	9.2 (100)	1.8 (50)	1.8 (25)	2.86 (35)	2.3 (50)	20.2 (75)	18.5 (100)	3.0 (50)	5.08 (58)		ns
Yellow-spotted Honeyeater	**3.0 (100)**	**0.8 (75)**	**0.5 (50)**	**4.0 (100)**		0.21 (21)	**0.5 (25)**	0.5 (25)	0.3 (25)			36.6	***
Lovely Fairy-wren	2.5 (50)			1.0 (25)									
Zebra Finch	2.5 (25)	2.0 (50)									3.08 (25)		ns
White-bellied Cuckoo-Shrike	2.3 (100)	0.5 (25)	2.0 (100)	0.5 (50)	2.0 (100)	2.07 (85)	1.8 (100)	0.8 (50)	1.0 (50)	1.0 (100)	2.17 (92)		ns
Northern Fantail	**2.3 (100)**	0.3 (25)	**0.5 (50)**	**0.8 (25)**	**0.5 (25)**	**0.86 (57)**	**1.5 (100)**		0.3 (25)		0.17 (17)	25.2	**
White-browed Robin	**2.3 (100)**			**3.0 (75)**		**0.28 (21)**		**0.3 (25)**	**0.3 (25)**			34.3	***
Brown-backed Honeyeater	2.0 (50)	1.0 (50)	0.3 (25)			2.07 (50)	6.3 (75)	2.8 (50)	1.8 (50)	2.0 (50)	2.42 (66)		ns
Peaceful Dove	2.0 (75)	1.8 (75)	2.3 (75)	1.0 (50)	0.5 (25)	1.9 (57)	1.0 (50)	0.5 (25)	0.5 (25)	1.0 (50)	2.0 (58)		ns
Yellow Honeyeater	**2.0 (75)**	0.5 (25)	**2.8 (100)**			**1.5 (78)**	0.5 (25)	0.3 (25)	**0.8 (75)**		**0.8 (42)**	24.7	**
Fairy Martin	2.0 (25)							0.3 (25)					
Bar-shouldered Dove	2.0 (100)	1.0 (75)	2.0 (75)	2.0 (75)	0.3 (25)	1.36 (57)	0.5 (25)	0.3 (25)	0.3 (25)	1.0 (100)	0.58 (33)		ns

Species	7.2.3	7.2.3x2	7.2.4	7.3.25	7.12.31	7.3.19	7.3.20	7.1.2	7.3.6x1	7.3.7x1	7.3.8	H	p
Broad habitat	CCF	CCF	CCF	CCF	EOF	EOF	EOF	EST	PS	PS	TTW		
No. of quadrats	2	2	2	2	2	7	2	2	2	1	6		
No. of samples	4	4	4	4	4	14	4	4	4	2	12		
Little Shrike-Thrush	**1.8 (75)**	**0.5 (50)**		**2.3 (100)**			**0.8 (50)**					42.1	***
Yellow-bellied Sunbird	**1.5 (75)**	**2.8 (75)**	**0.8 (50)**			0.28 (14)		**1.8 (75)**	**1.0 (75)**		0.33 (8)	26	**
Dusky Honeyeater	**1.5 (75)**	**2.0 (100)**		**2.0 (100)**		0.21 (14)		**0.8 (50)**	**0.3 (25)**		0.08 (8)	35.8	***
Varied Triller	**1.5 (75)**		0.3 (25)	**1.3 (75)**	0.3 (25)	**0.36 (28)**	**1.3 (75)**	**1.0 (75)**	0.3 (25)		0.17 (16)	20.1	*
Fairy Gerygone	**1.5 (50)**	**1.3 (50)**		**2.5 (100)**				**0.5 (25)**				37.7	***
Red-winged Parrot	1.5 (50)					0.57 (7)	0.8 (25)						ns
Mistletoebird	1.5 (100)	1.5 (75)	2.3 (75)	2.0 (100)	2.3 (75)	1.5 (71)	0.5 (50)	1.0 (100)	0.8 (50)	0.5 (50)	1.17 (66)		ns
Helmeted Friarbird	1.3 (75)	1.0 (75)	1.3 (75)	1.3 (75)	1.0 (50)	1.36 (50)	0.5 (25)	1.3 (75)	2.3 (75)	0.5 (50)	2.3 (92)		ns
Gould's/Little Bronze-Cuckoo	**1.3 (50)**	**0.8 (50)**		**0.5 (25)**					**0.3 (25)**			20.8	*
Leaden Flycatcher	1.3 (100)	0.5 (25)	1.3 (75)	1.0 (50)	1.5 (75)	1.5 (78)	1.5 (75)	0.8 (50)	1.0 (75)	0.5 (50)	1.42 (66)		ns
Striated Pardalote	1.0 (50)					0.38 (14)	0.8 (25)				0.5 (25)		ns
Brush Cuckoo	1.0 (50)	0.5 (25)		0.5 (25)	0.3 (25)	0.36 (35)	0.3 (25)		0.3 (25)	0.5 (50)	1.0 (58)		ns
White-throated Needletail	1.0 (50)					0.14 (14)		5.0 (25)			0.83 (8)		ns
Scaly-breasted Lorikeet	1.0 (25)		3.5 (25)				1.3 (25)	5.0 (50)	1.0 (50)	1.5 (50)	0.67 (8)		ns
Rainbow Bee-eater	0.8 (50)	2.0 (75)	0.8 (25)	0.5 (50)		0.93 (28)			2.3 (50)		0.8 (33)		ns
Figbird	0.8 (50)	1.3 (50)	1.0 (50)	1.0 (50)	1.3 (50)	1.86 (64)	1.5 (75)		1.5 (25)		0.5 (16)		ns
Scarlet Honeyeater	0.8 (50)		0.5 (50)	1.5 (75)	1.3 (25)	1.0 (42)	1.0 (50)	0.3 (25)	0.3 (25)		1.3 (58)		ns
Lemon-bellied Flycatcher	**0.8 (50)**		**0.3 (25)**		**1.3 (100)**	**1.0 (64)**		**0.5 (50)**	**0.5 (25)**		**0.83 (58)**	18.5	*
Common Koel	0.8 (50)			0.5 (50)	0.3 (25)	0.29 (21)					0.17 (17)		ns
Australian Brush-turkey	0.8 (50)			0.5 (25)									
White-rumped Swiftlet	0.8 (25)		3.0 (25)			0.28 (7)	2.3 (50)		0.5 (25)				ns
Rufous Fantail	**0.8 (25)**			**1.3 (100)**								48	***
Spangled Drongo	0.5 (50)	1.3 (100)	1.0 (75)	1.0 (75)	2.3 (75)	1.5 (64)	1.0 (50)		0.3 (25)	0.5 (50)	1.42 (66)		ns
Forest Kingfisher	0.5 (50)		0.3 (25)	0.3 (25)	1.0 (25)	0.78 (42)	1.3 (75)	0.3 (25)	0.8 (50)	0.5 (50)	1.2 (58)		ns
Cicadabird	0.5 (25)		0.3 (25)	0.3 (25)	0.8 (50)	0.42 (35)	0.5 (25)				0.17 (16)		ns
Blue-winged Kookaburra	0.5 (25)			0.5 (50)	0.8 (50)	0.7 (35)		0.3 (25)	1.0 (50)	1.0 (50)	0.5 (25)		ns
Pacific Baza	0.5 (25)						0.5 (25)						
Welcome Swallow	**0.3 (25)**	**0.8 (75)**						**0.8 (50)**				31.5	***
Pheasant Coucal	0.3 (25)		0.3 (25)	0.5 (50)	0.8 (50)	0.57 (35)			1.0 (50)		0.08 (8)		ns

Spectacled Monarch	**0.3 (25)**		**1.8 (75)**								35.8	***
Emerald Dove	0.3 (25)		0.3 (25)			0.3 (25)						
Rufous Whistler	0.3 (25)			0.8 (50)	0.42 (28)	1.3 (75)				0.5 (33)		ns
White-winged Triller	0.3 (25)				0.14 (7)							
Royal Spoonbill	0.3 (25)											
Pallid Cuckoo	0.3 (25)											
Cockatiel		10.3 (50)					7.5 (25)					
Whistling Kite		0.8 (50)						0.5 (25)	0.5 (50)	0.08 (8)		ns
Black Butcherbird		0.5 (50)					0.3 (25)					
White-bellied Sea-Eagle		0.5 (50)										
Red-tailed Black-Cockatoo		0.5 (25)				0.3 (25)				0.33 (8)		
Brown Goshawk		0.3 (25)	0.3 (25)									
Great Bowerbird		0.3 (25)			0.21 (7)							
Pied Imperial Pigeon		0.3 (25)					0.5 (25)					
Sacred Kingfisher		0.3 (25)					0.3 (25)					
Black-necked Stork		0.3 (25)							0.5 (50)			
Eastern Curlew		0.3 (25)										
Red-backed Fairy-wren			2.3 (75)	1.5 (75)	1.14 (28)			2.8 (75)	3.0 (50)	1.42 (33)		ns
White-breasted Woodswallow			2 (25)					0.5 (50)		0.5 (8)		ns
Little Friarbird			17.8 (50)		0.14 (7)		6.5 (25)	7.5 (25)		0.42 (25)		ns
Grey Fantail			0.8 (75)	0.3 (25)	1.0 (50)	0.86 (42)	1.5 (75)	0.3 (25)		0.42 (25)		ns
Pale-headed Rosella			0.5 (25)	0.3 (25)		0.5 (21)			1.0 (50)	0.08 (8)		ns
Brown Honeyeater			0.3 (25)	0.3 (25)		0.14 (7)		1.3 (50)	1.0 (25)	0.17 (8)		ns
Black-faced Cuckoo-shrike			0.3 (25)			0.28 (14)	0.5 (25)		0.3 (25)	0.33 (16)		ns
White-throated Gerygone			0.3 (25)									
Graceful Honeyeater				**2.5 (100)**		**0.21 (14)**					41.1	***
Azure Kingfisher				0.8 (50)								
Rose-crowned Fruit-Dove				0.8 (25)								
Large-tailed Nightjar				0.5 (50)		0.07 (7)				0.08 (8)		ns
Noisy Pitta				0.5 (50)								
Channel-billed Cuckoo				0.5 (25)		0.21 (7)				0.08 (8)		
Shining Flycatcher				0.5 (25)			0.5 (25)					
Silvereye				0.5 (25)								

Species	7.2.3	7.2.3x2	7.2.4	7.3.25	7.12.31	7.3.19	7.3.20	7.1.2	7.3.6x1	7.3.7x1	7.3.8	H	p
Broad habitat	CCF	CCF	CCF	CCF	EOF	EOF	EOF	EST	PS	PS	TTW		
No. of quadrats	2	2	2	2	2	7	2	2	2	1	6		
No. of samples	4	4	4	4	4	14	4	4	4	2	12		
Australian Owlet-nightjar				0.3 (25)	0.3 (25)	0.07 (7)					0.17 (16)		ns
Olive-backed Oriole				0.3 (25)		0.14 (7)					0.42 (33)		ns
Dollarbird				0.3 (25)		0.14 (7)					0.17 (16)		ns
White-throated Nightjar				0.3 (25)							0.08 (8)		
Pied Monarch				0.3 (25)									
Sulphur-crested Cockatoo					0.3 (25)	0.071 (7)		0.3 (25)			0.67 (16)		ns
Fan-tailed Cuckoo					0.3 (25)	0.07 (7)							
Little Lorikeet						1.42 (7)							
Laughing Kookaburra						0.28 (21)	0.8 (50)				0.08 (8)		ns
Noisy Friarbird						0.21 (14)					0.42 (25)		ns
Australian Raven						0.14 (7)			0.3 (25)				
Bush Stone-Curlew						0.14 (7)					0.08 (8)		
Brown Falcon						0.071 (7)							
Painted Button-Quail						0.07 (7)					0.08 (8)		
Red-browed Finch						0.07 (7)							
Topknot Pigeon							1.3 (25)						
Bridled Honeyeater							0.8 (25)						
Superb Fruit-Dove							0.3 (25)						
Tree Martin								2.3 (25)	3.8 (25)				
Magpie-Lark								2 (25)	0.5 (25)		0.33 (25)		ns
Australian White Ibis								12.8 (50)					
Plum-headed Finch								12.5 (25)					
Black-fronted Dotterel								1.5 (25)					
White-necked Heron								0.8 (25)					
Black Kite								0.5 (50)					
White-faced Heron								0.5 (25)					
Double-barred Finch								0.5 (25)					
Nankeen Kestrel								0.3 (25)					
Grey-tailed Tattler								0.3 (25)					

Red-kneed Dotterel								0.3 (25)					
Pied Cormorant								0.3 (25)					
Tawny Grassbird									0.3 (25)	1.0 (50)			
Jacky Winter									0.3 (25)				
Large-billed Gerygone									0.3 (25)				
Buff-banded Rail										0.5 (50)			
Budgerigar											3.3 (16)		
Pied Currawong											0.33 (8)		
Blue-faced Honeyeater											0.17 (8)		
Brahminy Kite											0.08 (8)		
Red-backed Button-Quail											0.08 (8)		
Barking Owl											0.08 (8)		
Masked Owl											0.08 (8)		
Pied Butcherbird											0.08 (8)		
Straw-necked Ibis											0.08 (8)		
AMPHIBIANS													
Bufo marinus	**3.3 (100)**	2.5 (100)	1.8 (25)	**31.0 (100)**	0.8 (25)	**5.07 (57)**			1.0 (50)	**47.0 (100)**	**4.08 (58)**	25.9	**
Litoria caerulea	2.3 (25)												
Litoria rubella	1.0 (50)	0.3 (25)	0.8 (25)			0.21 (14)			0.8 (50)		0.5 (33.)		ns
Limnodynastes ornatus	0.8 (50)	2.5 (75)	**7.0 (100)**	**16.0 (100)**	1.8 (25)	1.14 (50)			**3.5 (50)**	**2.5 (50)**	**4.3 (58)**	22.5	*
Litoria alboguttata	0.3 (25)												
Limnodynastes convexiusculus			1.3 (25)	**2.8 (50)**	1.0 (50)	**6.71 (78)**	1.8 (75)	0.3 (25)	**5.5 (50)**	**21.0 (100)**	**3.42 (50)**	19.4	*
Uperoleia mimula			1.0 (50)		0.3 (25)	0.85 (14)	1.0 (25)		0.3 (25)	6.0 (100)	2.0 (33)		ns
Litoria lesueuri				3.5 (50)									
Litoria nasuta				1.0 (25)		0.5 (21)	0.5 (25)		0.3 (25)	2.0 (100)	2.17 (50)		ns
Crinia deserticola				0.5 (25)		0.14 (7)				5.0 (50)	1.3 (17)		ns
Litoria gracilenta				0.3 (25)		0.07 (7)					0.08 (8)		
Litoria rothii				0.3 (25)							0.08 (8)		
Litoria fallax									0.3 (25)				
Litoria bicolor										5.0 (50)			
Litoria inermis										5.0 (50)			
Cyclorana novaehollandiae											1.3 (8)		

Species	7.2.3	7.2.3x2	7.2.4	7.3.25	7.12.31	7.3.19	7.3.20	7.1.2	7.3.6x1	7.3.7x1	7.3.8	H	p
Broad habitat	CCF	CCF	CCF	CCF	EOF	EOF	EOF	EST	PS	PS	TTW		
No. of quadrats	2	2	2	2	2	7	2	2	2	1	6		
No. of samples	4	4	4	4	4	14	4	4	4	2	12		
MAMMALS													
Melomys cervinipes	**3.8 (100)**	**4.8 (100)**		**6.0 (100)**	**4.8 (50)**	2.07 (14)	**6.8 (50)**	0.5 (25)				33.2	***
Melomys burtoni	**11.3 (100)**	1.8 (50)	1.0 (50)		0.3 (25)	**3.23 (57)**	**2.5 (50)**	1.8 (25)	**16.8 (75)**	**32.0 (100)**	0.58 (25)	26.2	**
Rattus sordidus	0.5 (25)		0.3 (25)		1.5 (25)	1.42 (36)			2.5 (75)	11.5 (50)	3.3 (50)		ns
Pseudomys delicatulus	0.3 (25)	**2.3 (100)**	**1.5 (100)**			0.42 (36)	0.5 (50)	**0.8 (50)**	**1.0 (75)**		**1.3 (50)**	22.3	*
Isoodon macrourus	0.3 (25)		0.3 (25)		0.5 (25)	0.36 (28)			0.3 (25)		0.08 (8)		ns
Uromys caudimaculatus	0.3 (25)		0.3 (25)						0.3 (25)				
Planigale maculata	0.3 (25)			0.3 (25)		0.28 (28)	0.3 (25)	1.3 (75)	0.8 (50)		0.67 (33)		ns
Sminthopsis murina		0.3 (25)				0.21 (7)							
Macropus agilis		0.3 (25)				0.07 (7)		0.3 (25)					
Rattus tunneyi			0.5 (25)										
Tachyglossus aculeatus			0.3 (25)										
Equus caballus					0.8 (25)	0.21 (14)	0.5 (25)				1.17 (17)		ns
Trichosurus vulpecula						0.36 (14)					0.42 (33)		ns
Mus musculus						0.07 (7)					0.42 (8)		
Sus scrofa							1.3 (25)	0.3 (25)					
Macropus giganteus									0.3 (25)		0.42 (17)		
Leggadina lakedownensis											0.08 (8)		
REPTILES													
Carlia storri	**6.3 (100)**		**11.0 (100)**	0.8 (25)	1.8 (50)	**7.23 (100)**	**5.5 (100)**	1.8 (25)	**7.3 (100)**	4.0 (100)	5.58 (92)	28.4	**
Carlia schmeltzii	**2.8 (100)**	0.3 (25)	**1.3 (50)**		**3.5 (100)**	0.36 (28)	**1.0 (25)**		**1.0 (25)**		0.3 (17)	27.9	**
Carlia aeratus/foliorum	**2.3 (75)**		**4.8 (100)**		**3.0 (100)**	**2.57 (86)**	**1.3 (50)**	0.8 (50)	0.3 (25)		**1.8 (42)**	27.6	**
Gehyra dubia	**1.8 (100)**	**1.8 (75)**	**1.0 (25)**			**0.57 (29)**		**0.5 (25)**			0.3 (17)	22	*
Ctenotus taeniolatus	**1.8 (100)**		**1.3 (75)**			**0.07 (7)**					**0.42 (17)**	35.7	***
Cryptoblepharus virgatus	0.8 (50)	1.8 (100)	1.3 (50)	0.3 (25)	1.0 (75)	1.86 (78)	0.5 (25)	1.8 (50)	1.8 (75)	2.0 (100)	2.3 (75)		ns
Varanus varius	0.5 (50)	0.5 (50)				0.07 (7)			0.3 (25)		0.17 (8)		ns
Heteronotia binoei	**0.5 (25)**	**1.0 (100)**				**0.07 (7)**						39.6	***
Ctenotus robustus	0.3 (25)	**8.3 (100)**	0.3 (25)		**2.0 (100)**	0.5 (14)	0.3 (25)	**0.8 (50)**	**0.8 (25)**		**2.3 (58)**	26.8	**
Diporiphora australis	0.3 (25)	**0.5 (25)**	**2.8 (50)**		0.3 (25)	**1.23 (71)**		**0.5 (25)**			**4.58 (75)**	21.6	*

Lialis burtonis	0.3 (25)		0.8 (50)			0.14 (14)		0.3 (25)		1.0 (50)		ns
Tiliqua scincoides	0.3 (25)				0.3 (25)						0.3 (8)	
Carlia jarnoldae				**1.3 (50)**	**5.3 (100)**						**0.17 (8)**	42.7 ***
Carlia pectoralis		1.5 (75)										
Morethia taeniopleura		1.3 (50)										
Varanus gouldii		0.5 (50)						0.3 (25)				
Ramphotyphlops unguirostris		0.3 (25)				0.14 (14)	0.3 (25)					ns
Ramphotyphlops sp2		0.3 (25)										
Chlamydosaurus kingii			0.8 (50)								0.33 (25)	ns
Furina ornata			0.3 (25)			0.07 (7)			0.3 (25)		0.08 (8)	ns
Carlia aeratus			0.3 (25)			0.07 (7)						
Simoselaps warro			0.3 (25)									
Carlia rostralis				**9.3 (100)**	**0.3 (25)**		**0.5 (50)**					42.1 ***
Eulamprus tenuis				**2.8 (100)**								58.9 ***
Glaphyromorphus punctulatus				**1.0 (75)**	**0.5 (50)**		**0.3 (25)**					32 ***
Carlia zuma				0.8 (25)			0.3 (25)					
Elseya latisternum				0.5 (25)								
Carlia munda		**1.8 (75)**		**0.3 (25)**	**0.3 (25)**	**0.07 (7)**						25.4 ***
Lampropholis delicata				**0.3 (25)**					**0.5 (50)**	**0.5 (50)**		23.4 **
Tropidonophis mairii				0.3 (25)						0.5 (50)		
Ramphotyphlops polygrammicus				0.3 (25)								
Delma tincta					0.5 (50)	0.07 (7)						
Varanus timorensis					0.5 (25)	0.21 (14)	0.3 (25)					ns
Menetia timlowi					0.3 (25)							
Demansia torquata					0.3 (25)							
Ramphotyphlops sp1						0.07 (7)						
Oedura rhombifer						0.07 (7)						
Egernia frerei							0.5 (25)					
Pygopus schraderi											0.08 (8)	

Table 3. Incidental vertebrate fauna data recorded for the Clemant State Forest survey. Only species not recorded in the quadrat samples are shown. Data indicate the total number of records for the species within the regional ecosystem types. Cleared = recorded on cleared land, dam = recorded at a dam, dist = recorded in disturbed vegetation to which a regional ecosystem type could not be assigned.

Common name	7.1.1	7.1.2	7.2.3	7.2.3x2	7.2.4	7.3.1	7.3.5	7.3.6x1	7.3.7	7.3.7x1	7.3.8	7.3.19	7.3.20	7.3.23	7.3.25	7.12.31	cleared	dam	dist
Habitat																			
BIRDS																			
Australian Pelican												1							
Great Egret		1		3															
Cattle Egret																			21
Intermediate Egret										1									
Striated Heron	2																		
Eastern Reef Egret				1															
Nankeen Night Heron							1					1							
Yellow-billed Spoonbill		3								1									
Pacific Black Duck																		1	
Australian Wood Duck										20									
Black Swan										1									
Wandering Whistling-Duck												1							
Plumed Whistling-Duck																		11	
Wedge-tailed Eagle												1							
Black-shouldered Kite																	1		
Osprey				4								1							
Masked Lapwing		3																2	
Beach Stone-Curlew			2	2															
Great Knot				1															
Bar-tailed Godwit				26															
Whimbrel	1			2															
Pied Oystercatcher				2															
Lesser Crested Tern				9															
Common Tern				10															
Gull-billed Tern				1															
Wompoo Fruit-Dove														1					
Little Kingfisher	2														1				

Southern Boobook												1						
Rufous Owl	1											1			2			
Tawny Frogmouth					2		1				4	2			3	1		
Richard's Pipit		2															1	
Pale-yellow Robin														1				
Black-faced Monarch															1			
Willie Wagtail																	1	
Golden-headed Cisticola						1											2	
Macleay's Honeyeater															1			
Chestnut-breasted Mannikin											3						3	
Australian Magpie											2							
Torresian Crow						3							1		1			
AMPHIBIANS																		
Litoria infrafrenata															1			
Litoria microbelos						5					5	5						
Limnodynastes tasmaniensis								1										
MAMMALS																		
Canis lupus dingo		1																
Hydromys chrysogaster	1													1	1			
Perameles nasuta													1					
Petaurus breviceps											3	6	3		6	2		
Acrobates pygmaeus												1						
Chaerephon jobensis															1			1
Mormopterus loriae																		1
Mormopterus planiceps															1			
Saccolaimus flaviventris																		1
Taphozous australis															1			
Hipposideros diadema															2			
Rhinolophus megaphyllus												4		1				
Rhinolophus Philippinensis														1				
Chalinolobus nigrogriseus															1			
Kerivoula papuensis												1		1				
Miniopterus australis												7	1	1	3			

Common name	7.1.1	7.1.2	7.2.3	7.2.3x2	7.2.4	7.3.1	7.3.5	7.3.6x1	7.3.7	7.3.7x1	7.3.8	7.3.19	7.3.20	7.3.23	7.3.25	7.12.31	cleared	dam	dist
Habitat																			
Myotis molluccanum														2	6				
Nyctophilus bifax												3		2	3				
Scotorepens sanborni															4			1	
Vespadelus pumilus															1				
Vespadelus troughtoni												1							
Nyctimene robinsoni															1				
Pteropus alecto					2				3		3	10			2	1			
Pteropus scapulatus						1					1	2		1					
REPTILES																			
Antaresia maculosus												2							
Aspidites melanocephalus												1							
Morelia amethestina														2	1				
Morelia spilota															1				
Boiga irregularis											3								
Dendrelaphis punctulata				1							1	1			1				
Cacophis churchilli														1					
Demansia atra													1						
Pseudechis porphyriacus														1					
Rhinoplocephalus nigrescens											1	1							
Oedura castelnaui											1								
Physignathus lesueurii															4				
Carlia rubrigularis														2					
Cryptoblepharus plagiocephalus																1			
Saproscincus basiliscus														2					
Hemisphaeriodon gerrardii														4					

(western border of the study area abutting upland areas). Other species that were vagrant, seasonal or simply poorly known, and more typical of dry tropical open woodlands, included the Pallid Cuckoo, Fan-tailed Cuckoo, Black-faced Monarch, Plum-headed Finch, Little Lorikeet, *Leggadina lakedownensis, Rattus tunneyi, Macropus robustus, Pygopus schraderi, Oedura castelnaui, Carlia zuma* and *Cacophis churchilli*. Cockatiels and Budgerigars were recorded in abundance in the last season of sampling (March-April 2002) coincident with a period of below average rainfall in western Queensland.

Habitat characteristics of the Regional Ecosystems

Nine habitat variables showed significant variation between regional ecosystems (Table 4). The closed/clumped forests were all characterised by high litter cover and low perennial grass cover. They also demonstrated a high canopy cover (or basal area) and high log cover (though those ecosystems with large gaps between clumps exhibited lower values). The eucalypt open forests have in common an intermediate crown cover, and high rock and perennial grass covers. The estuarine regional ecosystem had high perennial grass, perennial sedge and bare ground covers, whilst having very low canopy crown cover, basal area, log and rock cover. The paperbark swamps share characters such as high basal area, high canopy cover, moderate to very high sedge cover and low bare ground cover. The tea-tree woodland sites feature high perennial grass and bare ground covers, and a moderate perennial sedge cover.

Species Relationships with Regional Ecosystems

Species richness was highest in the closed/clumped forest habitats (28-38 species per quadrat) and moderate to high for tea-tree woodland and eucalypt open forest (22-26 species per quadrat) (Table 2). Species richness for all animal classes was elevated in closed/clumped forest, whilst in other habitats the taxa with highest species richness varied (amphibian, bird and mammal in the paperbark swamps, birds in the estuarine habitats, amphibian and reptiles in eucalypt open forest, Table 2).

Thirty-five species, comprising 16 birds, three frogs, three mammals and 13 reptiles, demonstrated significant variation in abundance between regional ecosystems (Table 2). Of the bird species, a majority were associated with mesic (humid and densely vegetated) habitats, with White-browed Robin, Little Shrike-thrush, Spectacled Monarch, Rufous Fantail, Fairy Gerygone, Yellow-spotted Honeyeater and Graceful Honeyeater most abundant in closed/clumped forest (particularly REs 7.3.25 and 7.2.3) (Table 2). Other species such as the Lemon-bellied Flycatcher and White-throated Honeyeater were more typical of open eucalypt forest (REs 7.3.19 and 7.12.20) (Table 2).

Of the reptiles recorded, the skinks varied most significantly between regional ecosystem types, though there was less partitioning between mesic and xeric (dry with open vegetation) environments than birds. *Eulamprus tenuis*,

Table 4. Mean score for habitat variables with significant variation between regional ecosystems. The correlation coefficient (H) and the significance in variation in abundance were tested via Kruskal-Wallis ANOVA. Probability levels are *p<0.5, **p<0.01, ***p<0.001. Highest five mean score indicated in bold, and lowest six indicated by italics. CCF = closed/clumped forest; EOF = eucalypt open forest; EST = estuarine; PS = paperbark swamp; TTW = tea-tree woodland.

Regional Ecosystem	7.2.3	7.2.3x2	7.2.4	7.3.25	7.3.19	7.3.20	7.12.31	7.1.2	7.3.6x1	7.3.7x1	7.3.8	H	p
Broad habitat	CCF	CCF	CCF	CCF	EOF	EOF	EOF	EST	PS	PS	TTW		
Litter cover (%)	**65.3**	**27.3**	**42.0**	**79.8**	*25.3*	**36.8**	*18.0*	*12.8*	*22.8*	*6.5*	*15.0*	33.6	***
Canopy crown cover (%)	**47.5**	*22.5*	*16.0*	**100.0**	*31.9*	**45.0**	*40.0*	*4.0*	**44.0**	**50.0**	*27.8*	37.3	***
Basal area (cubic metres)	**24.5**	*8.5*	**17.5**	**22.0**	*16.7*	*13.0*	*15.0*	*4.0*	**26.5**	**31.0**	*11.5*	41.2	***
Perennial grass cover (%)	*18.0*	*24.8*	*26.0*	*0.5*	**54.9**	*28.8*	**42.8**	**52.0**	**69.3**	*6.5*	**35.0**	36.9	***
Canopy height (m)	**14.0**	*4.5*	*15.0*	**21.0**	**20.1**	**21.0**	*16.5*	*9.0*	**28.0**	*10.0*	*10.8*	42.0	***
Logs cover (%)	**7.0**	**3.0**	*1.8*	**3.3**	*1.3*	**2.8**	*2.0*	*0*	*1.5*	*0.5*	**2.2**	30.1	***
Bare ground cover (%)	*6.3*	**36.0**	*8.5*	*6.8*	**8.8**	**13.0**	*8.5*	**13.3**	*4.0*	*4.5*	**30.9**	26.0	***
Perennial sedge cover (%)	*0*	*0.3*	*0.6*	**4.3**	*0.7*	*0.4*	*0.8*	**11.5**	**1.5**	**82.5**	**2.9**	24.9	**
Rock cover (%)	*0*	*0*	*0*	**3.3**	**1.5**	**1.8**	**23.3**	**1.0**	*0*	*0*	*0*	35.4	***

Glaphyromorphus punctulatus and *Carlia rostralis* were three species that were abundant in the riparian closed/clumped forest (RE 7.3.25), whereas species such as *Carlia jarnoldae*, *C. munda*, *C. schmeltzii* and *Ctenotus robustus* were recorded more commonly in RE 7.12.31 and tea-tree woodland (RE 7.3.8), though the latter three species were also abundant in dune closed/clumped forest (RE 7.2.3, 7.2.3x2). *Ctenotus taeniolatus* was also abundant in these latter three regional ecosystems. *Carlia storri* was one of the most common and widespread species recorded in the survey and was abundant in the full range habitats sampled, except for the closed forest on dune ridges (RE 7.2.3x2, Table 2).

Two geckos *Heteronotia binoei*, and also to a lesser extent *Gehyra dubia*, were highly associated with dune and strandline closed/clumped forest (REs 7.2.3 and 7.2.3x2, Table 2). *Heteronotia binoei* was regularly found by searching during the day under piles of bark at the base of trees, or accumulated bark around logs, most often within the dune habitats. Conversely the dragon *Diporiphora australis* was most abundant in tea-tree woodlands (RE 7.3.8, Table 2). Few amphibians were recorded regularly enough to tease out patterns of variation between regional ecosystems, apart from *Limnodynastes ornatus* and *L. convexiusculus*, both commonly recorded in most regional ecosystem types, but typically were more abundant in mesic *Melaleuca* dominated swamp and closed forest habitats (REs 7.3.7x1 and 7.3.25, Table 2).

Only three mammals were recorded in sufficient numbers to identify patterns of variation between regional ecosystems. *Melomys cervinipes* was most abundant in closed/clumped forest and *Eucalyptus* forest (REs 7.3.20 and 7.3.25), but was also common in the dune and strandline vegetation (REs 7.2.3 and 7.2.3x2, Table 2). The often-sympatric *M. burtoni* was widespread across a variety of habitats, but more so in paperbark swamps and dune vegetation (REs 7.3.7x1, 7.3.6x1, 7.2.3, Table 2). Similarly *Pseudomys delicatulus* was prevalent in a range of regional ecosystem types, but abundant in sandy dune closed/clumped forest and tea-tree woodlands (REs 7.3.8, 7.2.4, 7.2.3x2, Table 2).

A number of species were recorded in all or almost all regional ecosystems sampled by the quadrat methods, and could perhaps be considered generalists. These include Bar Shouldered Dove, Peaceful Dove, Rainbow Lorikeet, Brush Cuckoo, Forest Kingfisher, White-bellied Cuckoo-Shrike, Spangled Drongo, Leaden Flycatcher, Scarlet Honeyeater, Helmeted Friarbird, Brown-backed Honeyeater, Mistletoebird, Figbird and the skink *Cryptoblepharus virgatus*.

Seasonal variation

Thirty-five vertebrate species, comprising ten bird species, two frogs, four mammals and five reptiles, varied significantly in abundance between seasons (Table 5). Birds included the highest number of seasonal variants, with a majority being more abundant in the pre-wet period. These included species such as granivores, seasonal migrants, resource trackers and insectivores (Sulphur-crested Cockatoo, Pheasant Coucal, Common Koel, Cicadabird, Brown-backed Honeyeater and Figbird). A similar mix of guilds was recorded for the March to May period, including aerial insectivores, foliage insectivores and nectarivores (Rainbow Bee-eater, Grey Fantail, Rufous Whistler and Scarlet Honeyeater). Amphibians indicated little seasonal pattern, *Limnodynastes convexiusculus* and *Litoria nasuta* being more abundant in the March to May period, whilst *Limnodynastes ornatus* and *Litoria rubella* more plentiful the October to November period. Similarly *M. burtoni* was common in the post-wet period and *Rattus sordidus* and *Isoodon macrourus* more common in the pre-wet samples. Reptile species and families demonstrating seasonal patterns were also evenly spread *Demansia torquata*, *Delma tincta*, *Carlia munda* and *Varanus timorensis* were recorded in higher numbers in the March May period compared to *Tiliqua scincoides*, *Carlia schmeltzii* and *Diporiphora australis*, which were higher in the October to November period. Ground cover variables indicated that litter cover significantly increased in the pre-wet season, whereas in the post-wet samples total ground cover, annual and perennial grass, sedge and forb cover were highest.

Adequacy of survey methods

Of the 7366 individual fauna records collected, 639 (representing 21 species) were from cage and Elliott traps (8382 trap nights), 1244 records (48 species) from pitfalls (1176 trap nights), 604 records (23 species) from reptile searches (216 15x30m searches), 2482 records (110 species) from bird counts (122 one-ha bird counts), 52 records (16 species) from bat trapping (21 harp trap, 3 mist net, 1 trip line nights), 311 records (14 species) from spotlighting (52 spotlight hours) and 2033 records (214 species) from incidentals records. A total of 116 species were recorded only from a single technique. The frequency of unique species records was highest within the incidental survey with all taxa represented and in proportion to the total species richness for these taxa across the entire survey (Figure 2). However, pit-fall, Elliott and cage trapping and spotlighting contributed a large number of unique reptile and mammal records. Naturally, specialised targeted techniques such as bird counts and bat trapping (harps, mist-nets and Anabat detecting) identified a significant proportion of birds and microchiropteran bat species, respectively.

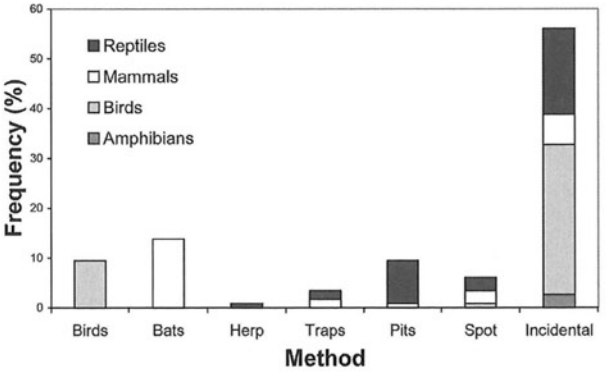

Figure 2. The total percent frequency of species (from all species recorded at Clemant) recorded uniquely by any one survey method. Birds = bird counts, Bats = harp trap, mist net, trip line or Anabat detector, Traps = Elliotts and Cages, Pits = pitfall traps, Spot = spotlighting, Incidental = observations during the course of other activities, Herp = timed reptile searches, Spot = opportunistic spotlighting (walking or driving).

Table 5. Seasonal differences in abundance for species recorded over all quadrats. Only species indicating significant variation are tabulated. Data represents mean abundance across the 30 paired quadrat sites. Z = the Wilcoxon matched pairs test statistic. Highest values for each species are indicated in bold. Probability levels are *p<0.5, **p<0.01, ***p<0.001.

Species	Post-wet	Pre-wet	Z	p
Peaceful Dove	**2.33**	0.7	3.1	**
Sulphur-crested Cockatoo	0.13	**0.23**	4.3	***
Pale-headed Rosella	0	**0.43**	2.4	*
Pheasant Coucal	0.1	**0.57**	4.5	***
Common Koel	0.03	**0.37**	4.2	***
Rainbow Bee-eater	**1.53**	0.07	3.5	***
White-rumped Swiftlet	0	**1.0**	2.2	*
White-bellied Cuckoo-Shrike	**1.77**	1.57	2.2	*
Cicadabird	0.13	**0.43**	4.1	***
Little Shrike-Thrush	0.27	**0.43**	2.0	*
Rufous Whistler	**0.6**	0.1	3.6	***
Spangled Drongo	0.83	**1.43**	2.1	*
Grey Fantail	**0.9**	0.17	3.7	***
Scarlet Honeyeater	**1.2**	0.5	4.2	***
Helmeted Friarbird	0.9	**1.97**	2.8	**
Brown-backed Honeyeater	0.57	**3.37**	4.0	***
Yellow-bellied Sunbird	0.23	**1.07**	2.7	**
Zebra Finch	**1.83**	0	2.2	*
Figbird	0.57	**1.6**	4.5	***
Bufo marinus	5.0	**7.5**	3.5	**
Litoria nasuta	**1.17**	0.3	2.1	*
Litoria rubella	0.17	**0.5**	2.3	*
Limnodynastes convexiusculus	**5.47**	2.1	3.8	***
Limnodynastes ornatus	2.43	**4.2**	3.7	***
Equus caballus	0.30	**0.43**	4.1	***
Melomys burtoni	**5.67**	2.93	3.3	***
Rattus sordidus	1.6	**1.77**	3.6	***
Isoodon macrourus	0.1	**0.27**	4.4	***
Demansia torquata	**0.03**	0	4.7	***
Delma tincta	**0.1**	0	4.5	***
Diporiphora australis	0.73	**2.27**	3.0	**
Carlia munda	**0.07**	0.03	4.5	***
Carlia schmeltzii	0.63	**0.93**	2.2	*
Tiliqua scincoides	0	**0.17**	4.6	***
Varanus timorensis	**0.17**	0.03	4.6	***
Habitat variable				
Annual grass cover (%)	**3.5**	0.1	3.18	***
Forb cover (%)	**7.9**	3.1	4.26	***
Total ground cover (%)	**83.3**	65.8	3.94	***
Litter cover (%)	23.6	**35.3**	3.6	***
Perennial sedge cover (%)	**5.6**	3.9	2.7	**
Perennial grass cover (%)	**40.7**	34.3	2.36	*

Discussion

Species

The Clemant fauna survey is the most comprehensive fauna survey conducted in the Wet Tropics coastal lowlands to date. The 275 species of vertebrate fauna (Appendix 1) represent almost 50% of the total Wet Tropics vertebrate fauna (inclusive of upland and lowland species). Despite this figure there is likely to be a number of species still to be recorded. The high species richness seem to be in contrast to perceptions widely held by local natural resource managers that the southern lowland country of the wet tropics are of low biodiversity value due to its comparatively dry climate and unattractive appearance (Wright *et al.* 1980).

Previous vertebrate fauna surveys of adjacent areas have included: surveys of uplands rainforest (Mt Halifax, Williams *et al.* 1993a; Graham 1991), western high altitude woodlands (Townsville Field Training Area, Williams *et al.* 1993b), a coastal-mountain gradsect through Paluma (Winter *et al.* 1992), and surveys of the Townsville (Lavery 1968; Lavery and Johnson 1968) and Ingham (Lavery and Grimes 1974a, b) regions. In the historical Townsville and Ingham surveys, reptiles and amphibians were not surveyed. These publications present species lists with subjective abundance scores for very broad structural habitat types, and those that report on lowland areas do not distinguish which species were recorded from these areas. As such it is difficult to directly compare results of the Clemant survey to these, due to inherent differences in effort and methods. Simple comparisons indicate consistent species richness across surveys (e.g. 229 birds, 53 mammals, Lavery 1968; Lavery and Johnson 1968; 266 birds, 62 mammals Lavery and Grimes 1974a, b; 224 species, Winter *et al.* 1992), despite each of these surveys including rainforest.

Considering only the historic surveys that included lowland vegetation of Townsville and Ingham, a few variations in the species lists are worth highlighting:

- the lack of *Pseudomys delicatulus* and *Leggadina lakedownensis* in the Townsville and Ingham lists, the former being one of the more common rodents at Clemant;
- the absence of *Planigale maculata* and *Rattus tunneyi* from Townsville and low abundance in Ingham of both, the former being the most abundant dasyurid at Clemant;
- the absence of Rufous Bettong *Aepyprymnus rufescens* from Clemant, though recorded as common in open forest in both Townsville and Ingham;
- the absence of Masked, Rufous and Barking Owl and Australian Owlet-nightjar records in Townsville, though all except the Masked Owl were recorded in Ingham. All were present at Clemant, the Australian Owlet-nightjar being common;
- the seasonal presence of Budgerigar, Cockatiel and Plum-headed Finch at Clemant, all absent from the Townsville and Ingham lists;
- the presence of White-naped Honeyeater, Fuscous Honeyeater and Rufous-throated Honeyeater, Australian Bustard, Squatter Pigeon, Crimson Finch (all uncommon) from open forest around Townsville and Ingham, though all unrecorded from Clemant; and
- the common presence of Red-winged Parrots at Clemant (previously uncommon in Townsville and Ingham), but only a single sighting of Little Lorikeets (common in Ingham and Townsville).

These differences could be a result of different methods employed (e.g. shooting and break-back traps versus pitfall and Elliott), generalised habitat descriptions in these papers, long term temporal cycles, or evidence of genuine decline or increase in some species.

Species of conservation significance

A relatively high number of significant species were recorded during the survey and the habitats at Clemant may be important refuges for these fauna in the future. Fourteen species are listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) (Australian Government 1999), the *Queensland Nature Conservation (Wildlife Regulation) 1994* (QNCR) (Queensland Government 1994), and National Action Plans (Cogger *et al.* 2000, Duncan *et al.* 1999, Garnett and Crowley 2000, Lee 1995, Maxwell *et al.*, 1996, and Tyler 1997) (Table 6).

The Beach Stone-curlew inhabits beaches associated with estuaries or near mangroves, using fringing vegetation for shade and shelter, and nesting at the back of sandy beaches among tide debris (Marchant and Higgins 1993). The species is extremely sensitive to disturbance, habitat modification, (particularly at nesting sites) and nest predators, and as a result has declined in abundance in populated areas such as Townsville (Marchant and Higgins 1993). Two large nocturnal raptors, the Rufous and Masked Owl, were also recorded in a range of open woodland and closed forest types. The Rufous Owl is more widespread in dense vegetation, feeding on a range of terrestrial and arboreal mammals, birds and bats, whereas the Masked Owl prefers more open landscapes feeding more on terrestrial species (Higgins 1999). Both owls are threatened by habitat clearance and loss of roosting trees and breeding hollows (Debus and Rose 1994), and a decline in numbers of breeding pairs of the Rufous Owl and Masked Owl have been recorded in the Herbert District directly north of Clemant (Young and De Lai 1997). This is thought to be due to a combination of vegetation clearing for sugarcane and secondary poisoning via the consumption of rodents targeted by baiting programs (Young and De Lai 1997). A probable sighting of a Square-tailed Kite (rare, Queensland Government 1994) in south-eastern Clemant requires further investigation.

A single Squirrel Glider *Petaurus norfolcensis* was recorded from the aquaculture area adjacent to Clemant (WBM Oceanics Australia 1993). This is particularly significant as it lies just beyond the known southern extent of the range of the Mahogany Glider *Petaurus gracilis*. Given the difficulty in separating these animals in the field, it is possible that this record was *P. gracilis*. Regardless,

Table 6. Fauna species of conservation significance recorded from the lowlands of Clemant State Forest from all data sources. EPBC= Environment Protection and Biodiversity Conservation Act 1999, NCA= Nature Conservation (Wildlife Regulation) 1994 Reprint No. 2C, AP= Action Plans for Australian fauna, Cogger *et al.* (2000), Duncan *et al.* (1999), Garnett and Crowley (2000), Lee (1995), Maxwell ***et al.*** (1996) and Tyler (1997). Status categories are: E=Endangered, R=Rare,V=Vulnerable, RI = Rare or Insufficiently known, NT(c) = Near threatened (declined in abundance by over 50%), NT(d) = Near threatened (small population <3000 or unknown), LR(nt) =Lower risk, near threatened.

Species	Common name	EPBC	NCA	AP
Ephippiorhynchus asiaticus	Black-necked Stork		R	
Burhinus grallarius	Bush Stone-Curlew			NT(c)
Esacus neglectus	Beach Stone-Curlew		V	
Numenius madagascariensis	Eastern Curlew		R	
Sterna albifrons	Little Tern		E	
Ninox rufa queenslandiae	Rufous Owl		R	NT(d)
Tyto novaehollandiae kimberli	Masked Owl	V	V	NT(c)
Collocalia spodiopygius	White-rumped Swiftlet		R	
Sminthopsis murina	Common Dunnart			LR(nt)
Petaurus norfolcensis	Squirrel Glider			LR(nt)
Taphozous australis	Coastal Sheathtail-bat		V	LR(nt)
Rhinolophus philippinensis	Large-eared Horseshoe-bat	E	R	E
Kerivoula papuensis	Golden-tipped Bat		R	LR(nt)
Simoselaps warro	North-eastern Plain-nosed Burrowing Snake		R	RI

the presence of either species is very important, as the southernmost distribution of *P. gracilis* or the point of overlap or turnover to *P. norfolcensis*. Spotlight search effort within Clemant, including other historic surveys (Eyre 1992; Smith 1996; Van Dyck 1993; Burnett 1998; WBM Oceanics Australia 1993), now amounts to at least 120 hours, with only the single result for either animal being recorded (*P. norfolcensis*, WBM Oceanics Australia 1993). Surveys conducted mostly within the range of *P. gracilis* (Eyre 1992; Lyon 1993; Goldingay *et al.*1997) have shown that the rate of detection ranges from 10 to 18 hours per Mahogany Glider sighting. It seems that though *P. gracilis* and/or *P. norfolcensis* may possibly be present in Clemant, they are probably very uncommon and/or seasonal. Localities such as this, for species on the edge of their range, may prove to be important with the onset of greenhouse conditions, which may change vegetation distribution (Howden *et al.* 2003).

The worrying decline of small mammal abundance in savanna woodlands and monsoon rainforest of northern Australia has received recent attention (Woinarski *et al.* 2001). Apart from three abundant and disturbance–tolerant tropical species (*Melomys cervinipes*, *M. burtoni*, *R. sordidus*), small mammals at Clemant were generally captured in very low numbers. Three species are of particular note. *Rattus tunneyi*, a folivorous species once considered common, is now rarely encountered in north-eastern Queensland. It has been reduced in distribution possibly due to habitat degradation from introduced herbivores, tree clearing and weed invasion (Braithwaite and Griffiths 1996). It was recorded only once at Clemant, at a site which has never been grazed. Ungrazed or lightly grazed areas such as these may be key refuge for this species. At another site, the poorly known mouse *Leggadina lakedownensis* was captured twice within 3 days of each other. This species is apparently genuinely rare, with only 15 localities recorded in Queensland, despite extensive long-term surveys in parts of their range (Winter and Atherton 1984; Hannah and Thurgate 2001; Kutt 2004a). The distribution and conservation of this species in Queensland is discussed further in Kutt and Kemp (in press). Three records of *Sminthopsis murina* are of special interest as it is more typically encountered in upland woodlands on the western fringe of the Wet Tropics. Small dasyurids are notoriously difficult to capture and record, being naturally rare and trap-shy. As a consequence distributional knowledge is patchy and taxonomic resolution inadequate. There is also continuing confusion between the northern extent of this species and southern distribution of *Sminthopsis archeri*.

The microchiropteran bat fauna was species rich, a typical feature of Wet Tropics environments (Richards 1991). Two charismatic and rare species *Kerivoula papuensis* and *Rhinolophus philippinensis* were captured in harp traps placed in riparian and adjacent sclerophyll vegetation. Though only rediscovered in 1981 after being considered extinct in Australia (Churchill 1998), information regarding the distribution and habitat of *K. papuensis* is now available (Schulz 1995; Schulz and Wainer 1997). It is widely distributed along the Australian east coast from dry sclerophyll to dense rainforest vegetation (Churchill 1998). This spectacular bat is unique in being a specialised arachnivore, and utilising old gerygone and scrub-wren nests for roosting (Schulz 1995; Schulz and Wainer 1997, Churchill 1998). Given its wide distribution, this bat is less threatened than previously considered (Duncan *et al.* 1999). Conversely *R. phillipinensis* is a problematic species. There are two forms (large and small form), which are taxonomically ill defined (Cooper *et al.* 1998). They also exhibit morphological overlap with north-south clinal

variation (Thomson *et al.* 2001). The Clemant record is categorised as the "large form", but confusion still exists regarding its true identity (Kutt in press). Regardless, Clemant is clearly suitable habitat for both these species.

Only one reptile of listed conservation status was recorded: *Simoselaps warro*. This species is restricted to tropical woodlands north of Townsville (Wilson and Swan 2003). In Clemant it was recorded in a pitfall bucket on an old dune ridge, and it is possibly restricted to sandy environments being a burrowing species. The Eastern Hooded Scaly-foot *Pygopus schraderi*, though common in the arid and semi-arid regions of central Queensland, is rarely encountered in the north (Wilson and Swan 2003). One was recorded from a tea-tree woodland site. The skink *Carlia zuma* was previously considered endemic to the central Queensland coast around Mackay (Stuart-Fox *et al.* 2002), and the record for Clemant (from boulder-strewn riparian forest) represents a substantial biogeographical range extension. The White-lipped Tree Frog *Litoria infrafrenata* was recorded in *Melaleuca* forest along a minor creekline at the height of one of the wettest wet seasons, which is possibly the southern-most natural record of the species. It is generally restricted to the Wet Tropics and Cape York Peninsula bioregions, but many have been translocated in banana boxes and palm trees, and become resident in woodlands along the north-east coast of Australia (Barker *et al.* 1995).

Species relationships to regional ecosystems

Though there have been no similar systematic quantified surveys of the patterns and environmental determinants of flora and fauna in the lowland woodlands of northern Queensland, a range of studies in the Northern Territory monsoon tropical savannas provides some useful comparisons. These show that fauna assemblages are associated with substrate and moisture availability as expressed by broad habitat types (sandstone, swamp, woodland, monsoon rainforest), rather than floristic variation, with local-scale factors (moisture, substrate, soil, complexity) exerting greater influences on fauna patterns than disturbance such as fire (Woinarski and Gambold 1992; Menkhorst and Woinarski 1992; Woinarski *et al.* 1992; Woinarski 1993; Woinarski and Fisher 1995b). Birds of tropical woodland vegetation are, in particular, notoriously unpredictable in abundance and composition and driven by fluctuations in resource availability (Woinarski *et al.* 1988; Woinarski and Tidemann 1991).

Regional ecosystem mapping in the Wet Tropics bioregion (Queensland Herbarium, Environmental Protection Agency. 2003a, Queensland Herbarium, Environmental Protection Agency. 2003b) combine both floristic and landscape features (soils and landform) and should therefore provide a better predictor of particular fauna assemblages than simply vegetation mapping based on plant composition alone. The results of the Clemant survey indicate that many species were distributed across a range of regional ecosystem types, but often occurred in ecosystems with a similar structural character, soils or landform (e.g. soil type, ground cover, vegetation structure, minor landscape position). Other species had a specific association with a small number of regional ecosystems (or even a single regional ecosystem). In general, of the 191 species recorded in the quadrat samples, 57 (~30%) were recorded in five or more regional ecosystem types (36 birds, six amphibians, six mammals, nine reptiles). It is possible that the land type mapping (Kemp *et al.* 1999) and/or the regional ecosystem mapping (Queensland Herbarium, Environmental Protection Agency 2003b) could be refined to better reflect soil, landform and structural variation (as theoretically they should (Sattler and Williams 1999)), and as a result would show greater correlation with fauna assemblages. Even with improved mapping, however, it is likely that many species will range across a number of ecosystems.

The dune and riparian ecosystems (closed/clumped habitats) were consistently the most species rich sites. These sites were structurally diverse and this is a well-accepted coarse predictor of fauna community richness and composition (Wiens 1989). Species such as Yellow-spotted Honeyeater, Northern Fantail, Little Shrike-thrush, Fairy Gerygone, Rufous Fantail, Spectacled Monarch and *Melomys cervinipes* were abundant and these species are common in habitats with high architectural heterogeneity (Woinarski *et al.* 2002). Fossorial species require litter and shrub cover and generally decline with an increase of bare ground (Woinarski and Ash 2002). The high degree of log and litter cover in the closed/clumped habitats favoured a high abundance of the geckos *Gehyra dubia* and *Heteronotia binoei* both of which shelter under timber during the day (Wilson and Swan 2003). The skink *Glaphyromorphus punctulatus* was strongly associated with RE 7.3.25, which has especially high litter cover. The strong preference for the RE 7.3.25 by *Carlia rostralis* may specifically relate to the combination of closed habitat and rocky substrate, interspersed with open sandy areas for basking. This RE is also favoured by *Eulamprus tenuis*, which is strongly arboreal, and appeared to favour the large tree trunks of *Melaleuca leucadendra, M. fluviatilis* and *Lophostemon grandiflorus* trees, which are typical of the RE.

Two eucalypt open forest regional ecosystems at the base of the foothills (7.12.31 and 7.3.20) share species also found in closed/clumped habitats (Graceful Honeyeater, *Carlia munda, Glaphyromorphus pumilus, Melomys cervinipes*). To a degree (with the probable exception of *Carlia munda*), this is probably partly due to these sites being adjacent to the mountainous massif providing a more humid environment (and higher localised rainfall), and partly due to mutual ground cover complexity and high canopy cover. The scansorial/arboreal *M. cervinipes*, normally associated with closed/clumped forests, was also present in these structurally more complex eucalypt open forest ecosystems (7.3.20 and 7.3.25). Here the combination of high rock cover, tangles of vine (the introduced *Passiflora suberosa*), fallen timber, grass-trees and herbaceous ground cover, matches the structural complexity of their more typical habitats (Menkhorst and Knight 2003).

The paperbark swamps (dominated by *Melaleuca leucadendra, M. quinquenervia* or M. sp. aff. *viridiflora*) though supporting overall low species richness, sustained high numbers of amphibians and mammals. The relationship with frogs and grassy wetlands needs little explanation and vegetation ground cover is a strong determinant of small mammal presence and abundance (Dickman *et al.* 1999). Aspects

of this pattern are discussed further in the section **Seasonal differences.** The skink *Lampropholis delicata* was uncommon at Clemant, but most abundant in these sites, and this small reptile typically occurs in long unburnt sites with a dense and complex groundcover (Brown and Nelson 1992). The relatively high bird richness in 7.3.6x1 is possibly linked to the dense *Melaleuca* canopy, a significant seasonal flowering resource for honeyeaters such as White-naped Honeyeater, Dusky Honeyeater, Yellow Honeyeater, and Yellow-bellied Sunbird. Additionally the only records of Tawny Grassbirds and Buff-banded Rail were recorded in these swamps.

Tea tree woodlands (dominated by *Melaleuca viridiflora*) are widespread in the study area and many fauna species showed a firm abundance relationship with this habitat (e.g. Lemon-bellied flycatcher, *Pseudomys delicatulus, Ctenotus taeniolatus, Diporiphora australis, Ctenotus robustus*). Bird richness was high, possibly a combination of the *Melaleuca* canopy which provides a significant seasonal nectar and insect resource, but probably also due to the fairly broad range of structural types included in this extensive and well sampled (12 sites) ecosystem. The agamid *D. australis* was abundant in the tea tree woodlands, a habitat where bare ground cover is high: a feature typical of habitat of this species (Braithwaite 1987). Most species recorded in the tea tree woodlands also occur in adjacent eucalypt open forests. This is a typical pattern in tropical woodlands, were *Acacia* and *Melaleuca* dominated vegetation usually contain a subset of the species found in the more extensive eucalypt woodlands (Woinarski and Fisher 1995a, b). The sandy soils, which are prone to waterlogging, also accounts for high abundance of the burrowing amphibians *Limnodynastes convexiusculus* and *L. ornatus*.

The most ubiquitous habitat type was the eucalypt open forest. This habitat was characterised by intermediate to high species richness for all taxa, in particular RE 7.3.19 (all taxon) and RE 7.12.31 (high reptile richness). Some bird species were particularly abundant in these forests, including Lemon-bellied Flycatcher, White-throated Honeyeater and Northern Fantail, whereas other typical woodland species were recorded here exclusively, such as Laughing Kookaburra, Noisy Friarbird, Fan-tailed Cuckoo and Brown Falcon. The ground cover was usually fairly dense and grassy, favouring *Melomys burtoni, Carlia storri, Carlia aeratus/foliorum*, and *Tiliqua scincoides*. Some of the reptiles (*Ctenotus robustus, Carlia schmeltzii and C. jarnoldae*) preferred the sites that provided a combination of bare rock and boulders and dense vegetation (large-bodied reptiles such as *Ctenotus robustus* have been shown to be strongly associated with high ground cover (Thurgate 1997)). The relationship between small mammals and dense ground cover has been mentioned previously.

The estuarine habitats supported the lowest diversity of species, as the extreme conditions (highly saline ground stratum, mangroves, exposed saline soils) are suitable to few terrestrial species. Despite this *Planigale maculata* was abundant here, as was *Ctenotus robustus*, both trapped in pitfalls within the dense, Marine Couch *Sporobolus virginicus* cover. A number of honeyeaters widespread in mangroves (Yellow-bellied Sunbird, Dusky Honeyeater, Varied triller, Fairy Gerygone, Kutt 1997) were abundant, and there was a suite of aquatic birds and aerial insectivores common in these intertidal zones (Schodde *et al.* 1982) that were recorded nowhere else in Clemant (Welcome Swallow, Australian White Ibis, Black-fronted Dotterel, Nankeen Kestrel, Red-kneed Dotterel, Grey-tailed Tattler).

Several other relationships between species and habitat characteristics were evident across different broad habitat types. The skinks *Carlia jarnoldae, C. schmeltzii* and *Ctenotus robustus* were recorded frequently in RE 7.12.31, a particularly rocky eucalypt open forest type, but were also abundant in the dune closed/clumped forest and tea tree woodlands (REs 7.2.3, 7.2.3x2, 7.3.8). The unifying predictor seems to be a high proportion of basking areas (rock or bare sandy ground), interspersed with adjacent litter cover. Similarly *Ctenotus taeniolatus* was common in these latter three REs for similar reasons. This fast moving diurnal skink is capable of shuttling quickly across bare areas (which quickly reach high temperatures), to dense shady clumps, and logs for feeding and sheltering (Heatwole and Taylor 1987). *Carlia storri* was ubiquitous in all quadrat samples and regional ecosystems, and this diverse genus of lizards has developed a wide range of habitat tolerances (Braithwaite 1987; Woinarski and Gambold 1992; Woinarski and Ash 2002). Though there is little information regarding *C. storri*, similar species (*C. longipes, C. munda*) have been recorded over a range of substrates and disturbance regimes (Braithwaite 1987; Woinarski and Ash 2002; authors' unpubl. data).

Pseudomys delicatulus is a colonising species that tends to be found in environments with sandy soils (reflecting its burrowing habit) and sparse vegetation cover (Braithwaite and Brady 1993). Though the relationship was not entirely clear in the sites sampled at Clemant, this rodent species was captured more frequently in RE types that contained relatively high proportions of bare, sandy ground cover and a moderate to sparse density of vegetation in each stratum (dune systems and tea-tree woodlands).

Seasonal differences

The tropical savanna woodlands of northern Australia are important seasonal habitat for a suite of migratory bird species (Blakers *et al.* 1984; Schodde and Mason 1999). However, the sampling periods used in this study (at either end of the wet season) were possibly not wholly adequate to capture the temporal and spatial variation in tropical savanna bird communities, which is typically driven by annual and long term cycles of resource pulses and decline (Woinarski *et al.* 1988; Woinarski and Tidemann 1991). True "dry season" (e.g. July-August) and "wet season" (e.g. January-February) sampling may have been more informative, however sampling over the wet season is usually difficult or impossible in such flood-prone lowland areas. Despite this a number of patterns were evident from the results of this survey.

Some species whose distribution is typically patchy or locally nomadic (e.g. granivores, honeyeaters) follow changes in water and food resources. For example, the pattern of seasonal abundance for granivores may be related to the availability of suitable seed sizes for feeding (e.g. the smaller Peaceful Dove and Zebra Finch more abundant in the pre-wet, the larger Sulphur-crested Cockatoo and

Pale-headed Rosella increase in the post-wet). Similarly flowering resources of certain canopy species may influence honeyeater abundance (e.g. Scarlet Honeyeater abundant in the post-wet, Helmeted Friarbird, Yellow-bellied Sunbird, Brown-backed Honeyeater abundant in the pre-wet). Other species varied seasonally according to regional (e.g. Rufous Whistler, Grey Fantail, Cicadabird, White-bellied Cuckoo-shrike) and continental (e.g. Rainbow Bee-eater, Common Koel, Spangled Drongo) migration patterns (Blakers *et al.* 1984). One example of long-term climatic patterning also occurred in April 2002. Large numbers of Cockatiels and Budgerigars were recorded in most habitats (including beach and mangrove habitats) throughout Clemant. The sudden influx was likely due to migration of these species in search of water and food resources after a period of extensive drought in inland Australia.

The patterns for reptiles at Clemant were unclear. Typically heliothermic organisms are most active in summer when there are higher diurnal and nocturnal temperatures (Heatwole and Taylor 1987; Fisher 2001). However, increases or decreases in abundance can relate to tolerance of ground cover (e.g. low cover and *Diporiphora australis*, Braithwaite 1987; high cover and *Delma tincta*, Fisher 2001), increased temperatures (e.g. *Tiliqua scincoides*, Heatwole and Taylor 1987) or patterns of prey availability (e.g. elapid snakes, varanids and increase in amphibians, small reptile numbers post-wet), though this can only be inferred.

Seasonal replacement in the most abundant mammal species was also recorded. In habitats where both *Rattus sordidus* and *Melomys burtoni* were recorded, *R. sordidus* declined after the wet season rains, whereas *M. burtoni* increased in abundance. This shift is in part due to life history characteristics of both species. Both occur in dense grass and sedgelands that are seasonally inundated, though whereas *M. burtoni* is an agile climber and nests in shredded vegetation in elevated sites (hollows, shrubs), *R. sordidus* is strictly ground-dwelling and burrowing (Begg *et al.* 1983; Redhead 1995). After flooding *R. sordidus* either migrate from the area or suffer increased mortality, thus declining.

Survey methods

Vertebrate fauna surveys usually employ a range of sampling methods, often using techniques at the whim or bias of the practitioners. Some techniques (pit-fall trapping, repeated site bird counts, microchiropteran bat surveys) are often omitted in favour of general searching (Lavery and Johnson 1968; Lavery and Grimes 1974a, b; Woinarski and Fisher 1995; Winter *et al.* 1992). The results for this survey indicate that though incidental data collection methods are more successful in recording many species (e.g. frogs, birds and incidental searches), other techniques provide valuable additional records, often for uncommon species or particular taxa (e.g. small mammal species and pitfall trapping). Even systematic hectare bird counts recorded a number of species not recorded in incidental lists, suggesting that repeated census at point localities is a valuable adjunct to large area searches (Watson 2003). Though the point may seem somewhat laboured especially when comparing the relative success of techniques designed to target separate taxa, the frequent failure of fauna survey in many parts of Queensland to meet minimum standards suggests otherwise. Conservation, management and planning decisions are often based on field data, and deficiencies in this information lead to misinterpretation and poor decision-making.

Many of the species recorded during this survey (n=53) were represented by a single record. This hints that a further suite of species may have been overlooked. Recent evaluation of pitfall trapping inventories of reptiles in extremely diverse assemblages in western Australia indicated that extensive effort was required to achieve a plateau in species accumulation curves (Thompson *et al.* 2003). A comparison of quadrat sampling techniques (like those employed here), with the fauna recorded in an adjacent gas pipeline trench, indicated that many species were not recorded in standardised sampling (Woinarski *et al.* 2000). These authors branded the discrepancy between the pipeline and the quadrat samples as a "different fauna", indicating that even standardised sampling failed to encapsulate all species present within an area. Time, personnel and financial constraints are always a limitation of any vertebrate fauna survey, though the information presented here unequivocally suggests that it is always better to err on the side of greater effort.

Biogeographic context

As its geographical position dictates (southern end of the Wet Tropics Bioregion bordering on the Brigalow Belt Bioregion), the area has a number of species which lie at the southern limit of their favoured Wet Tropics range, or which are more typical of the Brigalow Belt. Being positioned between the extreme north of the drier Northern Brigalow Belt and the southern Wet Tropics bioregions, this is a notable zone of faunal interchange. Regions such as this are known as biogeographic crossroads and have been considered of particular significance for conservation and protection because of their higher inherent diversity caused by this meeting of different fauna assemblages (Spector 2002). Whilst being marginal habitat for some of these species at their range limits, it nonetheless provides important areas for seasonal resource use over short-term or long-term climate cycles.

Similarly, several rainforest or high altitude species that are more typical of the mountainous ranges to the west of the Clemant lowlands (Paluma-Seaview subregion of the Wet tropics) occur in the eastern seaboard foothills of Clemant. Some of these species migrate altitudinally from winter to summer (Bridled Honeyeater, Wompoo Fruit-Dove, Pale-yellow Robin, Pied Monarch, Macleay's Honeyeater) (Blakers *et al.* 1984). Similarly a phenomenon known as the mountain mass effect may exert some influence: that is biota in habitat at the foot of mountain ranges may have a greater similarity in composition to that of the mountain, when compared to other identical habitat distant from that mountain (Brown and Lomilino 1999).

Conclusions

In a publication printed in 1980 and designed to celebrate the landscape and environmental features of the region between Ingham and the tip of Cape York, (touted as our "Northern Heritage"), scant mention is made of the biological values of non-rainforest vegetation (Wright *et al.* 1980). However, rainforest vegetation consists of only 759 000 ha (Webb and Tracey 1981) which is <10% of the area of the Wet Tropics and Cape York Peninsula. One short paper in this publication is titled " Good use of the Wet Tropical Lowland/Landscape", in which the author lauds the agricultural potential of these lowlands, and begrudgingly identifies urban and recreation (namely beach and rivers) as other possible uses (Teitzel 1980). Most astonishingly these sentiments are only 20 years old and therefore, not surprisingly, the majority of vegetation clearing of the coastal lowlands has occurred in the last few decades (Braby 1992; Van Dyck 1993; Forster 2000). Even between 1997 and 1999 the Herbert and Tully (southern) lowland subregions were among Queensland subregions with high clearing rates (Wilson *et al.* 2002). Obsession with tall wet and closed forests, and failure to understand the true landscape heritage of northern Australia (e.g. Keto and Scott 1980), has exacted a high price on the open woodlands and savannas in the Wet Tropics bioregion.

The southern lowlands of the Wet Tropics Bioregion have traditionally been omitted from targeted protection under conservation tenure (Webb 1966), and in particular, the far south has been deliberately excluded (Stanton and Godwin 1989). Consequently, as a State Forest, Clemant has been managed under a "multi-use" philosophy and thus has been subject to cattle and horse grazing, bee-keeping, leasing of areas with subsequent clearing for farming, erection of yards and buildings, high impact recreation (4WD, trail bikes, horse-riding), and experimental pine plantations. These combined disturbances have caused significant weed invasion (e.g. *Lantana camara* and *Hyptis suaveolens*) into relatively undisturbed areas. The recent conversion of parts of the uplands of Clemant to National Park, and a lowlands portion (to the east of the Bruce Highway) to Forest Reserve is an important step, though the priority still seems to be for gazettal of the remote uplands areas rather than lowlands. Future management of Clemant needs to address the results of past human impact, though the lack of foresight will now cause a public financial burden, potentially increasing negative sentiment regarding the conservation values of these lowland remnants.

Though Clemant is currently being spelled from grazing, the re-introduction of cattle cannot be ruled out in the future given its tenure, and the current trend towards using grazing as a fire management tool in State managed lands. Current weed infestations at Clemant occur in areas where stock activity and soil disturbance has concentrated (cattle yards, waterholes, pine plantations, creek flats). There is unequivocal evidence that cattle are significant weed vectors, and where native vegetation is largely intact, grazing causes a predominantly negative impact on plant and animal diversity (Fleischner *et al.* 1994; Landsberg *et al.* 2003). Recent surveys of grazing in conservation reserves in the United States have indicated that livestock grazing for restoration purposes is in fact counterproductive and increases the dominance of alien plants (Kimball and Schiffman 2003). It seems incongruous that consideration is being given to a fire management strategy (through grazing), that though potentially low maintenance and cost-effective, will cause biodiversity impacts, compounding the difficulty and expense of future management. This highlights a dilemma where there has been a shift in the philosophy of public environmental administration from more altruistic goals of nature conservation to one of risk management (Beckwith and Moore 2001).

This survey has shown that the biodiversity values of the southern Wet Tropics lowlands are as substantial as rainforest areas in the Wet Tropics, and yet are more poorly known. This reinforces the need for recognition and continued research in the coastal lowland ecosystems, including data on seasonal patterns of distribution and abundance, the effects of disturbance and management (e.g. fire, weeds and grazing), and information on lesser-known taxa such as fish and invertebrates. Despite very limited data there is already evidence that specialist Wet Tropics lowland butterflies are suffering dramatic decline due to habitat loss (Braby 1992; Forster 2000).

The woodlands to the south of Clemant are on the verge of agricultural or hobby farm expansion, but currently there are still substantial areas which so far remain undeveloped and largely ungrazed. There is now an urgent need to protect these landscapes before gradual encroachment of development cause irreversible damage. Part of the conflict in the management and protection of these tropical woodlands is the public perception of these environments. This apparently extends to tourism where northern Townsville (Thuringowa Shire) is advertised as a rainforest destination on roadside billboards as one drives into Townsville, despite there being a distinct lack of well-developed, easily accessible rainforest within 70 km by road of the city. It seems unfortunate that the municipality has not embraced its savanna pedigree, which has a unique character peculiar to the Townsville region. This is a significant issue during an era of off-reserve, community-based nature conservation. Coastal lowland vegetation needs to be celebrated by the local community, rather than ostracised as the poor cousin of the Wet Tropics World Heritage Area.

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APPENDIX 1

Appendix 1 Complete species list for the lowlands of Clemant State Forest including those from the current survey and additional species recorded from secondary sources: 1=WBM Oceanics (1993), 2=Atlas of Australian birds, 3= Dr. Scott Burnett, Queensland Parks and Wildlife Service (unpubl. data).

BIRDS

Phalacrocoracidae

Phalacrocorax varius, Pied Cormorant
Phalacrocora sulcirostris Little Black Cormorant (2)

Pelicanidae

Pelecanus conspicillatus, Australian Pelican

Ciconiidae

Ephippiorhynchus asiaticus, Black-necked Stork

Ardeidae

Ardea alba, Great Egret
Ardea ibis, Cattle Egret
Ardea intermedia, Intermediate Egret
Egretta garzetta, Little Egret (1)
Ardea pacifica, White-necked Heron
Butorides striatus, Striated Heron
Egretta novaehollandiae, White-faced Heron
Egretta sacra, Eastern Reef Egret
Nycticorax caledonicus, Nankeen Night Heron

Threskiornithidae

Platalea flavipes, Yellow-billed Spoonbill
Platalea regia, Royal Spoonbill
Threskiornis molucca, Australian White Ibis
Threskiornis spinicollis, Straw-necked Ibis

Anatidae

Anas superciliosa, Pacific Black Duck
Chenonetta jubata, Australian Wood Duck
Cygnus atratus, Black Swan
Dendrocygna arcuata, Wandering Whistling-Duck
Dendrocygna eytoni, Plumed Whistling-Duck

Accipitridae

Accipiter cirrhocephalus, Collared Sparrowhawk (1)
Accipiter fasciatus, Brown Goshawk
Aquila audax, Wedge-tailed Eagle
Aviceda subcristata, Pacific Baza
Elanus axillaris, Black-shouldered Kite
Haliaeetus leucogaster, White-bellied Sea-Eagle
Haliastur indus, Brahminy Kite
Haliastur sphenurus, Whistling Kite
Milvus migrans, Black Kite
Pandion haliaetus, Osprey

Falconidae

Falco berigora, Brown Falcon
Falco cenchroides, Nankeen Kestrel

Burhinidae

Burhinus grallarius, Bush Stone-Curlew
Esacus neglectus, Beach Stone-Curlew

Megapodiidae

Alectura lathami, Australian Brush-turkey

Turnicidae

Turnix maculosa, Red-backed Button-Quail
Turnix varia, Painted Button-Quail

Rallidae

Gallirallus philippensis, Buff-banded Rail

Charadriidae

Elseyornis melanops, Black-fronted Dotterel
Charadrius ruficapillus, Red-capped Dotterel (1)
Charadrius leschenaultii, Large Sand Plover (1)
Charadrius mongolus, Mongolian Sand Plover (1)
Erythrogonys cinctus, Red-kneed Dotterel
Vanellus miles, Masked Lapwing

Scolopacidae

Calidrus ruficollis, Red-necked Stint (1)
Calidris tenuirostris, Great Knot
Heteroscelus brevipes, Grey-tailed Tattler
Arenaria interpres, Ruddy Turnstone (1)
Limosa lapponica, Bar-tailed Godwit
Numenius madagascariensis, Eastern Curlew
Numenius phaeopus, Whimbrel
Tringa nebularia, Greenshank (1)

Haematopodidae

Haematopus longirostris, Pied Oystercatcher

Laridae

Larus novaehollandiae, Silver Gull (1)
Sterna bengalensis, Lesser Crested Tern
Sterna bergii, Crested Tern (1)
Sterna caspia, Caspian Tern (1)
Sterna albifrons, Little Tern (1)
Sterna hirundo, Common Tern
Sterna nilotica, Gull-billed Tern

Columbidae

Phaps chalcoptera, Common Bronzewing (1)
Chalcophaps indica, Emerald Dove
Ducula bicolor, Pied Imperial Pigeon
Geopelia humeralis, Bar-shouldered Dove
Geopelia striata, Peaceful Dove
Lopholaimus antarcticus, Topknot Pigeon
Ptilinopus magnificus, Wompoo Fruit-Dove
Ptilinopus regina, Rose-crowned Fruit-Dove
Ptilinopus superbus, Superb Fruit-Dove

Cacatuidae

Cacatua galerita, Sulphur-crested Cockatoo
Calyptorhynchus banksii, Red-tailed Black-Cockatoo
Nymphicus hollandicus, Cockatiel

Psittacidae

Aprosmictus erythropterus, Red-winged Parrot
Glossopsitta pusilla, Little Lorikeet
Melopsittacus undulatus, Budgerigar
Platycercus adscitus, Pale-headed Rosella
Trichoglossus chlorolepidotus, Scaly-breasted Lorikeet
Trichoglossus haematodus, Rainbow Lorikeet

Centropodidae

Centropus phasianinus, Pheasant Coucal

APPENDIX 1

Cuculidae

Cacomantis flabelliformis, Fan-tailed Cuckoo
Cacomantis variolosus, Brush Cuckoo
Chrysococcyx russatus/minutillus, Gould's/Little Bronze-Cuckoo
Cuculus pallidus, Pallid Cuckoo
Eudynamys scolopacea, Common Koel
Scythrops novaehollandiae, Channel-billed Cuckoo

Halcyonidae

Dacelo leachii, Blue-winged Kookaburra
Dacelo novaeguineae, Laughing Kookaburra
Todiramphus macleayii, Forest Kingfisher
Todiramphus sanctus, Sacred Kingfisher
Todiramphus chloris, Collared Kingfisher (1)

Alcedinidae

Alcedo azurea, Azure Kingfisher
Alcedo pusilla, Little Kingfisher

Coraciidae

Eurystomus orientalis, Dollarbird

Meropidae

Merops ornatus, Rainbow Bee-eater

Strigidae

Ninox connivens, Barking Owl
Ninox novaeseelandiae, Southern Boobook
Ninox rufa, Rufous Owl

Tytonidae

Tyto novaehollandiae, Masked Owl

Caprimulgidae

Caprimulgus macrurus, Large-tailed Nightjar
Eurostopodus mystacalis, White-throated Nightjar

Aegothelidae

Aegotheles cristatus, Australian Owlet-nightjar

Podargidae

Podargus strigoides, Tawny Frogmouth

Apodidae

Collocalia spodiopygius, White-rumped Swiftlet
Hirundapus caudacutus, White-throated Needletail

Artamidae

Artamus leucorynchus, White-breasted Woodswallow
Cracticus nigrogularis, Pied Butcherbird
Cracticus quoyi, Black Butcherbird
Gymnorhina tibicen, Australian Magpie
Strepera graculina, Pied Currawong

Hirundinidae

Hirundo ariel, Fairy Martin
Hirundo neoxena, Welcome Swallow
Hirundo nigricans, Tree Martin

Pittidae

Pitta versicolor, Noisy Pitta

Motacillidae

Anthus novaeseelandiae, Richard's Pipit

Campephagidae

Coracina novaehollandiae, Black-faced Cuckoo-shrike
Coracina papuensis, White-bellied Cuckoo-Shrike
Coracina tenuirostris, Cicadabird
Lalage leucomela, Varied Triller
Lalage sueurii, White-winged Triller

Petroicidae

Microeca fascinans, Jacky Winter
Microeca flavigaster, Lemon-bellied Flycatcher
Poecilodryas superciliosa, White-browed Robin
Tregellasia capito, Pale-yellow Robin

Pachycephalidae

Colluricincla megarhyncha, Little Shrike-Thrush

Pachycephalidae

Pachycephala rufiventris, Rufous Whistler

Dicrurdae

Monarcha melanopsis, Black-faced Monarch
Monarcha trivirgatus, Spectacled Monarch
Arses kaupi, Pied Monarch
Dicrurus bracteatus, Spangled Drongo
Grallina cyanoleuca, Magpie-Lark
Myiagra alecto, Shining Flycatcher
Myiagra cyanoleuca Satin Flycatcher (2)
Myiagra rubecula, Leaden Flycatcher
Rhipidura leucophrys, Willie Wagtail
Rhipidura fuliginosa, Grey Fantail
Rhipidura rufifrons, Rufous Fantail
Rhipidura rufiventris, Northern Fantail

Sylviidae

Cisticola exilis, Golden-headed Cisticola
Megalurus timoriensis, Tawny Grassbird

Maluridae

Malurus amabilis, Lovely Fairy-wren
Malurus melanocephalus, Red-backed Fairy-wren

Pardalotidae

Gerygone laevigaster, Mangrove Gerygone (1)
Gerygone magnirostris, Large-billed Gerygone
Gerygone olivacea, White-throated Gerygone
Gerygone palpebrosa, Fairy Gerygone

Meliphagidae

Entomyzon cyanotis, Blue-faced Honeyeater
Lichenostomus flavus, Yellow Honeyeater
Lichenostomus frenatus, Bridled Honeyeater
Lichmera indistincta, Brown Honeyeater
Meliphaga gracilis, Graceful Honeyeater
Meliphaga notata, Yellow-spotted Honeyeater
Melithreptus albogularis, White-throated Honeyeater
Myzomela obscura, Dusky Honeyeater
Myzomela sanguinolenta, Scarlet Honeyeater
Philemon buceroides, Helmeted Friarbird
Philemon citreogularis, Little Friarbird
Philemon corniculatus, Noisy Friarbird
Ramsayornis modestus, Brown-backed Honeyeater
Xanthotis macleayana, Macleay's Honeyeater

APPENDIX 1

Nectarinidae

Nectarina jugularis, Yellow-bellied Sunbird

Zosteropidae

Zosterops lateralis, Silvereye

Dicaeidae

Dicaeum hirundinaceum, Mistletoebird

Pardalotidae

Pardalotus striatus, Striated Pardalote
Lonchura castaneothorax, Chestnut-breasted Mannikin
Neochmia modesta, Plum-headed Finch
Neochmia temporalis, Red-browed Finch
Taeniopygia bichenovii, Double-barred Finch
Taeniopygia guttata, Zebra Finch

Oriolidae

Oriolus sagittatus, Olive-backed Oriole
Sphecotheres viridis, Figbird

Corvidae

Corvus coronoides, Australian Raven
Corvus orru, Torresian Crow

Ptilonorhynchidae

Chlamydera nuchalis, Great Bowerbird

AMPHIBIANS

Bufonidae

Bufo marinus, Cane Toad

Hylidae

Cyclorana novaehollandiae, New Holland Frog
Litoria alboguttata, Striped Burrowing Frog
Litoria bicolor, Northern Dwarf Tree Frog
Litoria caerulea, Green Tree Frog
Litoria fallax, Eastern Dwarf Tree Frog
Litoria gracilenta, Graceful Treefrog
Litoria inermis, Bumpy Rocketfrog
Litoria infrafrenata, White-lipped Treefrog
Litoria lesueuri, Stony-creek Frog
Litoria microbelos, Pygmy Rocketfrog
Litoria nasuta, Rocketfrog
Litoria rothii, Red-eyed Treefrog
Litoria rubella, Naked Treefrog

Myobatrachidae

Crinia deserticola, Chirping Froglet
Limnodynastes convexiusculus, Marbled Frog
Limnodynastes ornatus, Ornate Burrowing-Frog
Limnodynastes peronii, Striped Marshfrog
Limnodynastes tasmaniensis, Spotted Marshfrog
Uperoleia mimula, Torres Gungan

MAMMALS

Canidae

Canis lupus dingo, Dingo

Equidae

Equus caballus, Feral Horse

Suidae

Sus scrofa, Feral Pig

Macropodidae

Macropus agilis, Agile Wallaby

Macropus giganteus, Eastern Grey Kangaroo
Macropus robustus, Common Wallaroo (1)

Dasyuridae

Planigale maculata, Common Planigale
Sminthopsis murina, Common Dunnart

Muridae

Hydromys chrysogaster, Water Rat
Leggadina lakedownensis, Lakeland Downs Mouse
Melomys burtoni, Grassland Melomys
Melomys cervinipes, Fawn-footed Melomys
Mus musculus, House Mouse
Pseudomys delicatulus, Delicate Mouse
Rattus sordidus, Canefield Rat
Rattus tunneyi, Pale Field Rat
Uromys caudimaculatus, Giant White-tailed Rat

Peramelidae

Isoodon macrourus, Northern Brown Bandicoot
Perameles nasuta, Long-nosed Bandicoot

Petauridae

Petaurus breviceps, Sugar Glider
Petaurus norfolcensis, Squirrel Glider (1)

Phalangeridae

Trichosurus vulpecula, Common Brushtail Possum

Acrobatidae

Acrobates pygmaeus, Feathertail Glider (3)

Tachyglossidae

Tachyglossus aculeatus, Short-beaked Echidna

Molossidae

Chaerephon jobensis, Northern Freetail-bat
Mormopterus loriae, Little Northern Freetail-bat
Mormopterus planiceps, Southern Freetail-bat

Emballonuridae

Saccolaimus flaviventris, Yellow-bellied Sheathtailed-bat
Taphozous australis, Coastal Sheathtail-bat
Taphozous georgianus, Common Sheathtail-bat (1)

Hipposideridae

Hipposideros diadema, Diadem Horseshoe-bat

Rhinolophidae

Rhinolophus megaphyllus, Eastern Horseshoe-bat
Rhinolophus philippinensis, Large-eared Horseshoe-bat

Vespertilionidae

Chalinolobus nigrogriseus, Hoary Wattled Bat
Kerivoula papuensis, Golden-tipped Bat
Miniopterus australis, Little Bent-wing Bat
Myotis molluccanum, Northern Large-footed Myotis
Nyctophilus bifax, North Queensland Long-eared Bat
Scotorepens sanborni, Northern Broad-nosed Bat
Vespadelus pumilis, Eastern Forest Bat
Vespadelus troughtoni, Eastern Cave Bat

APPENDIX 1

Pteropodidae

Nyctimene robinsoni, Queensland Tube-nosed Bat
Pteropus alecto, Black Flying-fox
Pteropus scapulatus, Little Red Flying-fox

REPTILES

Chelidae

Elseya latisternum, Eastern Snapping Turtle

Boidae

Antaresia maculosus, Spotted Python
Aspidites melanocephalus, Black-headed Python
Morelia amethestina, Amethystine Python
Morelia spilota, Carpet Python

Colubridae

Boiga irregularis, Brown Tree Snake
Dendrelaphis punctulata, Common Tree Snake
Tropidonophis mairii, Keelback

Elapidae

Cacophis churchilli, snake
Demansia atra, Black Whipsnake
Demansia torquata, Collared Whipsnake
Furina ornata, Orange-naped Snake
Pseudechis porphyriacus, Red-bellied Black Snake
Rhinoplocephalus nigrescens, Eastern Smalleyed Snake
Simoselaps warro, North-eastern Plain-nosed Burrowing Snake

Typhlopidae

Ramphotyphlops polygrammicus, blind snake
Ramphotyphlops sp1, unidentified blind-snake
Ramphotyphlops sp2, unidentified blind-snake
Ramphotyphlops unguirostris, Claw-snouted Blind Snake

Gekkonida

Gehyra dubia, Dubious dtella
Heteronotia binoei, Bynoe's Gecko
Oedura castelnaui, Northern Velvet Gecko
Oedura rhombifer, Zigzag Velevet Gecko

Pygopodidae

Delma tincta, Excitable Delma
Lialis burtonis, Burton's Legless Lizard
Pygopus schraderi, Eastern Hooded Scaly Foot

Agamidae

Chlamydosaurus kingii, Frill-necked Lizard
Diporiphora australis, Eastern Two-line Dragon
Physignathus lesueurii, Eastern Water Dragon

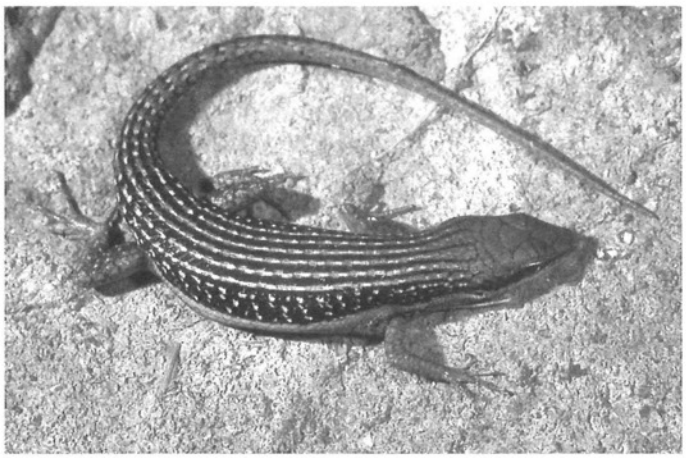
Scincidae

Carlia aeratus, skink
Carlia aeratus/foliorum, skink
Carlia jarnoldae, Lined Rainbow-skink
Carlia munda, Shaded-litter Rainbow-skink
Carlia pectoralis, Open-litter Rainbow-skink
Carlia rostralis, skink
Carlia rubrigularis, Northern Red-throated Skink
Carlia schmeltzii, Robust Rainbow-skink
Carlia storri, skink
Carlia zuma, skink
Cryptoblepharus plagiocephalus, Callose-palmed Shinning-skink
Cryptoblepharus virgatus, Cream-striped Shinning-skink
Ctenotus robustus, Robust Ctenotus
Ctenotus taeniolatus, Copper-tailed Skink
Egernia frerei, Majors Skink
Eulamprus tenuis, skink
Glaphyromorphus punctulatus, Fine-spotted Mulch-skink
Lampropholis delicata, skink
Menetia timlowi, skink
Morethia taeniopleura, Fire-tailed Skink
Saproscincus basiliscus, skink
Hemisphaeriodon gerrardii, Pink-tongued Lizard
Tiliqua scincoides, Eastern Blue-tongue Lizard

Varanidae

Varanus gouldii, Gould's Goanna/Sand Monitor
Varanus timorensis, Spotted Tree Monitor
Varanus varius, Lace Monitor

APPENDIX 2



The spectacular male *Carlia jarnoldae* is one of the more striking of skinks at Clemant. These skinks prefer environments with patches of sand or rock.

Photo: A. Kutt

APPENDIX 2

Typical eucalypt open forest in Clemant. The structural diversity and grassy high ground cover ensures a high species richness for most fauna groups.

Photo: J. Kemp

Golden-tipped Bat (*Kerivoula papuensis*) is listed as Rare under the Queensland Nature Conservation Act. This spectacular bat is adorned with bright, golden-tipped hairs and is remarkable for being a specialist spider-eater.

Photo: A. Kutt

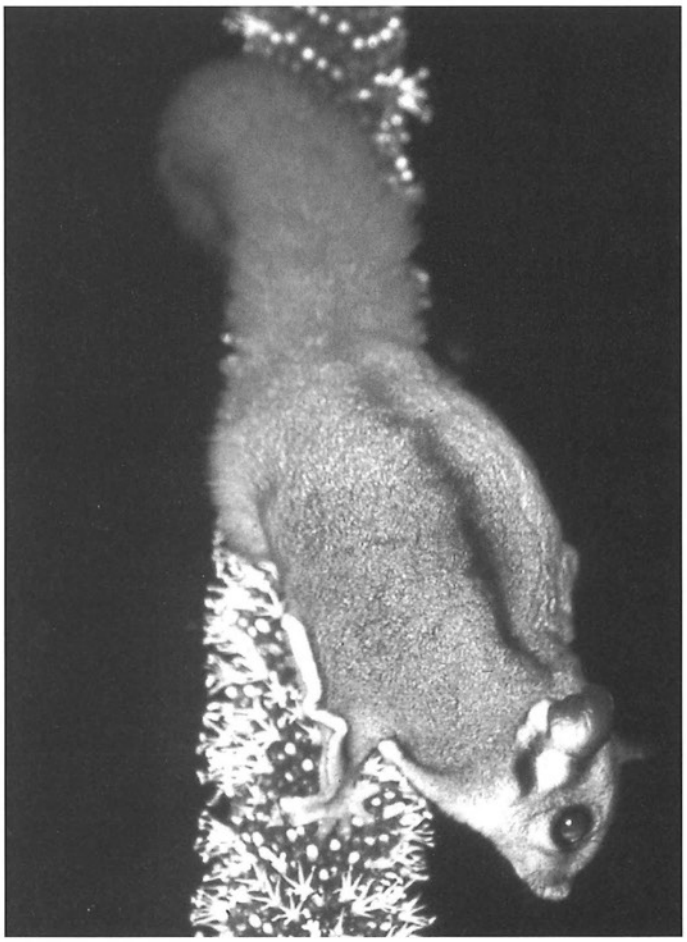
The elusive *Leggadina lakedownensis*. A total of two individuals were captured at the same site (in pitfalls) within three days of each other. This species is possibly both naturally rare and trap-shy.

Photo: A. Kutt

Limnodynastes ornatus is one of the most common frogs in Clemant, and come in an enormous variety of colours and patterns.

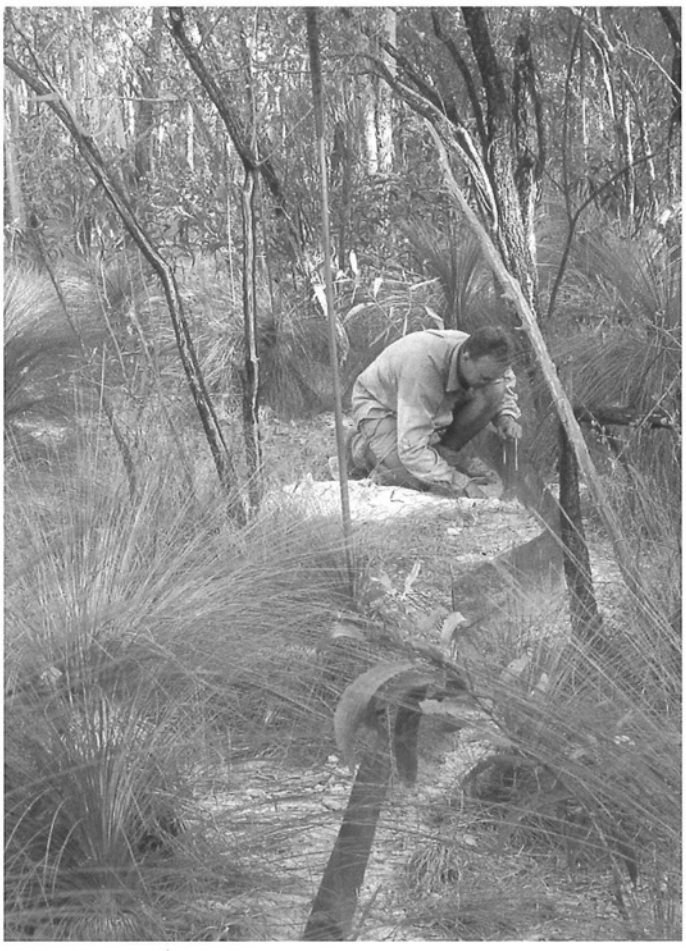
Photo: A. Kutt

APPENDIX 2



The Sugar Glider (*Petaurus breviceps*) is abundant in Clemant particularly in the more structurally diverse eucalypt open forest communities. Rufous forms were sighted that are similar in coloration to the Mahogany Glider (*Petaurus gracilis*).

Photo: A. Kutt



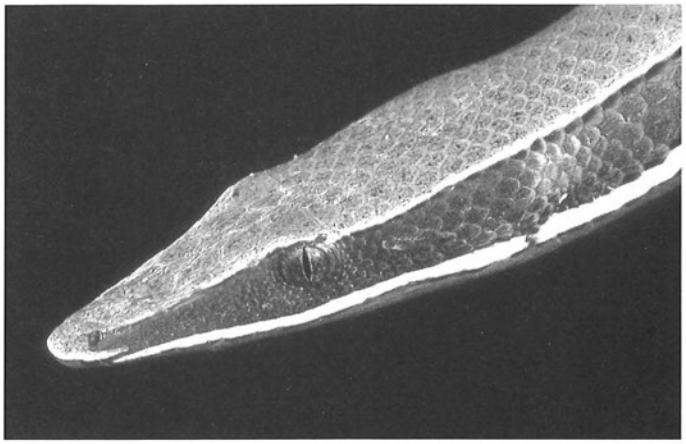
Setting up a pitfall trap line in tea tree woodland. Each pitline takes approximately 40 minutes to construct.

Photo: J. Kemp

APPENDIX 2

Planigale maculata is the most common (and most photogenic!) Dasyurid in Clemant.

Photo: A. Kutt

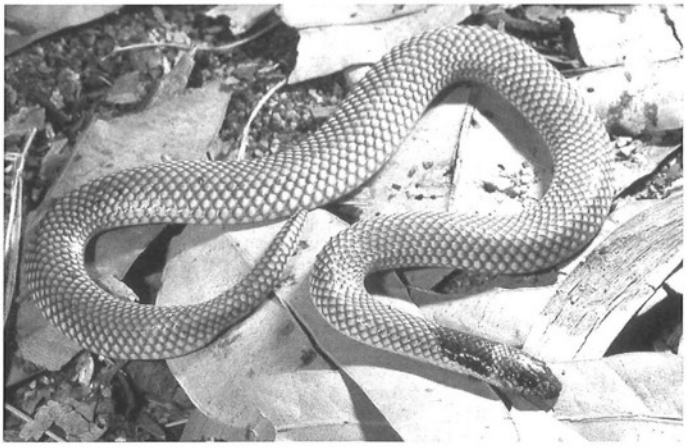


Relatively uncommon, but widespread in a range of habitats, this large gorgeous legless lizard (*Lialis burtoni*) often displays a remarkable array of patterns.

Photo: A. Kutt

Typical riparian forest ("closed/ clumped forest") RE 7.3.25 of *Melaleuca leucadendra* (weeping paperbark) with vine forest elements. A much-favoured haunt of microchiropteran bats and a rich assemblage of birds.

Photo: J. Kemp



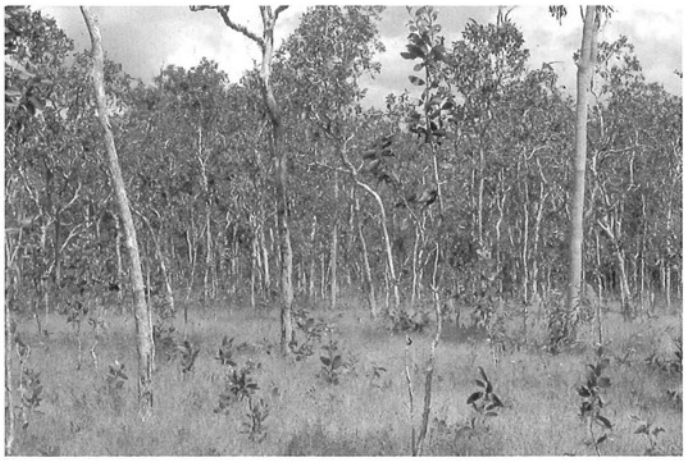
Simoselaps warro listed as Rare under the Queensland Nature Conservation Act, was captured only once during the survey in a stranded dune community (RE 7.2.4). This attractive burrowing species may favour sandy soils.

Photo: A. Kutt

APPENDIX 2

Typical tea-tree woodland with *Melaleuca viridiflora* over grass-tree with pale sandy-clay soils which are seasonally inundated. These communities support an extremely diverse frog fauna.

Photo: J. Kemp



A grassy example of tea-tree woodland with *Melaleuca viridiflora.* These communities, though deceptively simple in appearance, support a high species richness of both fauna and flora.

Photo: J. Kemp

This small common frog (*Uperoleia mimula*) is readily heard during the day after rains, but is not easy to find due to its ventriloquist skills. To add to their cryptic behaviour, they call from hidden locations such as small hollows or under leaves.

Photo: A. Kutt